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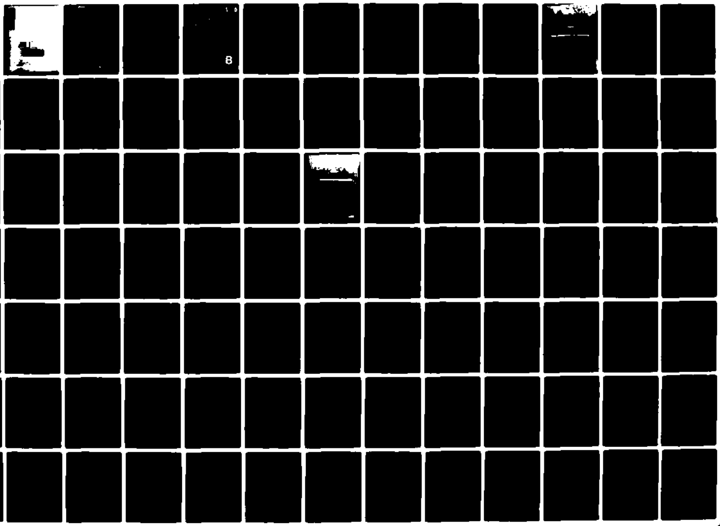

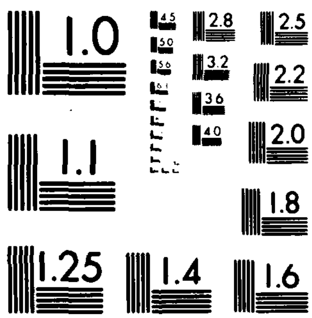

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The purpose of this study is to help decision makers determine future water resource needs of the Delaware River Basin area and ways of meeting these needs. This report undertaken in 1975 for the U.S. Army Corps of Engineers by an independent consultant firm comprises a brief review of the technical engineering planning performed in the development of the project in regards to the adequacy of preliminary project planning, the use of statistics in project formulation, planning procedures, euthrophication and other water quality considerations etc.

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A COMPREHENSIVE STUDY OF THE TOCKS ISLAND LAKE PROJECT AND ALTERNATIVES

JUNE 1975

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REVIEW OF TOCKS ISLAND LAKE PROJECT B

INTRODUCTION

This "Comprehensive Study of the Tocks Island Lake Project and Alternatives" is divided into five volumes or parts as follows:

A -- Analysis of Service Areas and Resource Needs

B -- Review of Tocks Island Lake Project

C -- Analysis of Alternatives to Supply Resource Needs

D -- Institutional Alternatives

E -- Land Use and Secondary Effects of the Tocks Island Lake Project

Brief descriptions of each of these five parts is contained in the Introduction in the Part A volume. Also presented in that volume is a summary of the project's background and development; a table of contents for the complete study; and listings of Study Management Team members and Consultants involved in the study effort.

CONTENTS - PART B

FIGURES

VII.A. PROJECT NEED AND DESIGN ASSUMPTIONS

This chapter comprises a brief review of the technical engineering performed in the development of the project to determine whether pre-authorization and preconstruction planning was adequate to establish the need and technical feasibility of the project. The analysis was based on review of documents prepared by the Corps of Engineers, Philadelphia District, as follows:

House Document No. 522, Delaware River Basin, New York, New Jersey, Pennsylvania, and Delaware, August, 1962, Eleven Volumes

Design Memorandum No. 1, Site Selection March 1965.

Design Memorandum No. 1, Site Selection, Supplement No. 1, September 1967.

Design Memorandum No. 2, Hydrology, Hydraulic and Hydropower Capacity, July 1965.

Design Memorandum No. 2, Hydrology, Hydraulic and Hydropower Capacity, Supplement No. 1, March 1966.

Design Memorandum No. 3, General Design Memorandum, July 1969.

Design Memorandum No. 3, General Design Memorandum Supplement No. 1, February 1968.

Environmental Impact Statement, September 1971.

Supplemental Data and Supplemental Information to the Final Environmental Impact Statement, 1974, Draft Copy.

Design Memorandum No. 6, Site Geology, October, 1967.

Design Memorandum No. 9, Embankment and Foundations, January 1970.

Design Memorandum No. 9, Embankment and Foundations Supplement No. 1, November 1970.

Design Memorandum No. 10, Spillway and Outlet Works, April 1972.

The Tocks Island Project was formulated as a part of a comprehensive plan to meet water resource needs for a 50 year period in the Delaware River Basin and contiguous area. The project, as authorized, included water supply, flood control, hydroelectric power and recreation. The project was developed to contribute to: (1) the future water supply needs of the Trenton-Philadelphia area and the contiguous service region; (2) the reduction of flood damages in the downstream areas of special importance to the Delaware Water Gap-to-Trenton section; (3) the satisfaction of future demand for electric energy in the area; and, (4) the satisfaction of the desire for non-urban recreation facilities of the regional population.

Two major limitations to project development were determined for pre-authorization studies. Site limitation at Tocks Island above elevation 428, involving costs for protecting the Port Jervis area, precluded extension of the scale of development at Tocks Island as authorized. The second limitation was whether satisfaction of additional and future requirements could be more economically achieved by development of other sites for major control projects.

VII.A.1.WATER SUPPLY

Available supplies were adequate to satisfy needs of the area at the time of preauthorization planning. Local interests expressed a desire for general conservation and development of water resources of the basin.

Gross water needs were projected for the water service area based on population and industrial growth projections to selected years. These projections indicated that the water supply from the project would be required during the forecast period and project life.

The most recent studies by the Corps (see General Design Memorandum No. 3) indicate that actual growth in the area between preautorization and preconstruction planning has generally paralleled the above growth projections. Therefore, the inclusion of water supply as a purpose of the Tocks Island Project is appropriate and viable.

VII.A.2.FLOOD CONTROL

The flood control storage was based on the optimum degree of protection that could be provided within the economic justification, based on tangible and intangible benefits, with consideration given to public safety and other factors which might warrant a greater degree of protection. The standard project flood was established as the upper limit of hazard protection to be sought. The storage provided was adequate to control 54 percent of the standard project flood to non-damaging proportions downstream. This would control all floods of record above the dam except the August, 1955 and March, 1936 floods and would eliminate the majority of downstream damages from the 1955 flood. Studies subsequent to preauthorization resulted in raising the pool from elevation 428 to 432 and increasing the storage by 66,800 acre-feet. The project is now designed to control all floods of record above the dam site.

Updated flood damage surveys by the Corps in 1966 and field reconnaissance by the Consultant in 1975 indicate that even with on-going flood proofing,

flood zoning and flood insurance programs there are still substantial existing developments in the flood plain which would be damaged. It is concluded that there is a positive need for flood control along the main stem of the Delaware River; the nominal increase in storage from preauthorization to preconstruction is warranted as downstream protection and is a major objective.

VII.A.3.LOCAL FLOOD PROTECTION

The criteria used provide adequate design for local protection works in the Port Jervis-Matamoras area and are consistent with criteria agreed to by all Federal agencies. The authorizing document did not stipulate any provisions for operational surcharge or for protection of Port Jervis. More recent studies provide for operational surcharge to elevation 436 providing four additional feet for flood control purposes and more firm reservoir operating criteria for major floods. This does not increase project costs for embankment and appurtenant structures. It does increase costs for land acquisition and local protection. Standard project flood plus a minimum of three (3) feet freeboard is provided for Port Jervis - Matamoras area which is adequate and consistent with above cited criteria.

VII.A.4.HYDROELECTRIC POWER

Preauthorization studies indicated a need for additional power facilities in the area. The New Jersey Power and Light Company expressed a willingness

to purchase and market at its expense any power generated by conventional hydropower facilities at the Tocks Island Project. They also proposed to build and operate, at their expense, a pump storage power project in conjunction with the Tocks Island development. The Federal Power Commission indicated there would be a ready market for all energy that could be produced economically at the site. The Department of the Interior, as the prospective marketing agency for federally produced energy, reviewed and generally concurred in the views of the Federal Power Commission. Pre-construction studies indicate on-stream power potential can be increased from a rated capacity of 46,000 KW (H.D. 522) to 70,000 KW. This can be developed separately in an above-ground power house by the Corps of Engineers as provided in the authorizing document or by the New Jersey companies as incidental to their development of hydroelectric pump storage power. Development in this manner does not involve any significant alteration of the Tocks Island Dam. The authorization for the project provides that construction of the dam shall proceed in a manner that permits development of those releases either incidentally by the companies or separately by the government, and that the Federal Power Commission shall decide which of the two alternative methods is to be followed. (See Senate Rept. 91-328, House Rept. 91-748, and PL 91-282) If conventional power potential is not developed by the companies it will be developed separately by the Corps of Engineers. Based on Corps of Engineer preauthorization and subsequent studies it is concluded that hydroelectric power is a viable project purpose and the design assumptions are concurred with.

VII.A.5. RECREATION

The area's need for recreation facilities was outlined in preauthorization planning. Based on interim development and population projections, the demand for recreational facilities will increase up to the limit of the project's potential. Preconstruction planning includes the 20 square mile lake area plus an additional 15 square miles of New Jersey and Pennsylvania land abutting the lake for recreation purposes. The outer project boundary is the inner boundary of the 75 square mile Delaware Water Gap National (land) Recreation Area, which surrounds the southern, eastern and western sides of the lake project. In view of the apparent needs, it is concluded that recreational aspects of the project are a viable project purpose.

VII.A.6. SUMMARY

The needs and design assumptions to satisfy the authorized project purposes are considered to be adequate and properly scoped in accordance with practices, standards, regulations and statutes governing the design of such projects under which the Army Corps of Engineers operates.

VII.A.7. ADDITIONAL PROJECT PURPOSES

Subsequent to preauthorization planning, objectives other than the authorized project purposes of flood control, recreation, conventional power and water supply were analyzed. These included (1) storage of water to augment flow and thereby improve water quality; (2) firming up data for pumped-storage power facilities; (3) conservation measures to preserve the fisheries for

sport and commercial purposes; (4) measures for protection of wildlife, (5) preservation of areas of environmental quality; and (6) preservation of areas and items of historical importance.

Studies for improvement of the quality of water in the river concluded that increased flows from the Tocks Island Reservoir would not materially alter the dissolved oxygen pattern in the estuary but would lower the chloride concentration. In order to increase the flow in the Delaware by the amount needed to insure water quality control would require a storage at Tocks Island Reservoir of 642,000 acre-feet. This is greater than the long-term storage available at the project. If even a portion of the long-term storage were available at the project for water quality control storage such storage would have detrimental effects on the water supply, power and recreation purposes of the project. The benefits produced by utilizing storage in Tocks Island for water quality control were less than the benefits when storage was utilized for other project purposes. The consultant concurs in the conclusions drawn regarding water quality storage. It is noted that release of water for downstream uses would augment seasonal low flow in the downstream mainstem of the Delaware River and help repel tidal intrusion of salt water in the mainstem below Philadelphia.

The consultant concurs in the results of the analysis for pumped-storage power that it is economically justified and could be developed in conjunction with the on-stream facilities.

The project has an adverse affect on sport and commercial fishing and wildlife protection; however, these items appear to be adequately addressed in the planning process and mitigating measures have been provided. Areas

of historical, ecological and archaeological interest will be preserved in their natural setting above normal pool elevation.

VII.B. ADEQUACY OF PRELIMINARY PROJECT PLANNING

The Comprehensive Plan developed under the auspices of the Delaware Basin Survey Coordinating Committee (House Document No. 522) was formulated to satisfy needs of the Basin for projects and services of water resources development. Measures considered were: (a) major control impoundments to regulate streamflow on main watercourses providing recreation, fish and wildlife habitat and production of hydroelectric power; (b) small control impoundments to regulate streamflow in local reaches and provide recreation; and (c) land and water use to eliminate or ameliorate need by environmental changes.

Broad principles followed were: (a) product and service needs were considered real and existing or to come into existence within the next 50 years; (b) satisfaction of expanding needs in a balanced manner with minimum investment in water resources and funds is appropriate; (c) the scale of each project should provide maximum excess benefits over costs.

Tocks Island was selected as one of the projects for early development to provide flood control, water supply, recreation and hydroelectric power. The project was formulated and planned in accordance with the above guidelines. Review of preauthorization planning indicates basin needs could be partially met by the Tocks Island Project. Physical and economic limitations of the site were adequately considered and economic justification for each project purpose demonstrated. It is concluded

that preliminary project planning was adequate and properly scoped as presented in the authorizing document according to governing procedures and regulations.

During review of the Delaware River Basin Report by the Board of Engineers for Rivers and Harbors, the Board considered the provisions contained in Public Law 87-88, Eighty-Seventh Congress, designated as the Federal Water Pollution Control Acts Amendments of 1961, amending the Water Supply Act of 1958 as they apply to the projects recommended for authorization. The storage of water to augment flows and thereby improve water quality was evaluated as potential project purpose. The Board also noted firm basic data for pumped storage power facilities were not available and they concurred that these facilities should not be recommended for construction at that time. These values for pumped power storage were determined in the interim and this potential purpose was included in preconstruction planning.

In addition, other added objectives of the project include sport and commercial fishing, wildlife protection, preservation of areas of natural beauty, and preservation of areas and items of historical importance. These have been appropriately addressed and considered in preconstruction planning.

Preconstruction planning generally followed the pattern of preauthorization planning and appears to conform with accepted Federal practice at the time except that the use of non-structural measures such as flood plain zoning, flood proofing, flood warning systems, etc. are only discussed briefly and adequate data to evaluate these as alternatives have not been included. Sufficient information should have been presented so

that viable alternatives considering structural and non-structural measures or combinations thereof could be weighed and evaluated in the project formulation process.

VII.C. CONSTRUCTION COST REVIEW

Review of construction costs was accomplished by study of applicable published documents and interviews with Corps of Engineer personnel who were involved with the original design and estimates. Primary documents consulted were the 1962 Comprehensive Report (House Document #522), General Design Memorandum (GDM) No. 3 (July 1969), GDM Supplement No. 1 (Feb. 1968), Environmental Impact Statement (Revised to Sept. 27, 1971), and the Supplemental Data Report and Supplemental Information to the Final Environmental Impact Statement TILP (1974). In addition, the yearly documents updating the 1968 estimate, FY68-FY74, were reviewed and analyzed.

The history of the studies connected with TILP extends back to 1955 when the Delaware Valley Reports Group (DVRG) was formed. Some 600 sites were investigated for all possible uses and these ultimately reduced to eight possibilities. The presently proposed TILP was the only one on the main stem of the Delaware River which fulfilled all project purposes according to the Corps' studies. Alternate locations on the main stem at Walpack Bend and Delaware Water Gap provided inadequate storage in the first case and proved to be far more expensive in the second.

In 1962 DVRG produced its Comprehensive Report, House Document 522. Congress authorized construction in the same year. Public hearings were held and the Corps proceeded with preliminary studies and Preconstruction Planning which led to production of General Design Memorandum No. 3 in 1968.

The preliminary design effort followed accepted professional practice. A Board of Consultants was formed to tap the expertise of outstanding professional practitioners. Design sections are reasonable and conservative. Analysis was thorough and the location of the dam is based on extensive soils investigation and analysis.

The latest cost estimate, FY74 (July 1974) has been escalated to December 31, 1974, the report baseline for economic analysis. In general, the update reports FY68 through FY74 involve escalation for inflation plus contingency amounts and allowances for known industry variances. In 1970, an amount was added for seismographic studies and subsequently removed in the second submission. In 1971, there was a significant change in amounts for real estate which was mandated by law affecting indemnification for relocation. Provision for seismographic studies was reestablished that year. In 1973, there was an added charge for General Services Administration office rental.

Review of the estimate assumes that indicated quantities are correct; unit prices were evaluated for reasonableness. The following comments are offered with respect to specific estimate items which are identified by cost account number.

01 Lands and Damages - This item is affected by the psychology of investment fever and legal restrictions rather than ordinary inflation. Therefore, escalation was based on past years' experience rather than on an inflation factor. In this category, Item 01.2, Wildlife Impact Mitigation Area, is simply the cost of land for wildlife.

02 Relocations - The largest part of this item is the relocation of Rte. 209 in Pennsylvania. A two lane highway meeting modern standards with limited access was assumed. Land necessary for the addition of two more lanes is included.

03 Reservoir Clearing - Appears Adequate.

04 Dams - Design effort was applied to produce the most economical design. A large rock removal necessitated by discovery of a clay flaw at the dam site is reused as embankment.

06 Fish and Wildlife Facilities - Although knowledge of shad cycles and basic requirements is sparse, experts predict a resurgence of shad migration due to the effect of pollution control. Extensive fish ladders and attraction facilities are part of the project design.

07 Power Facilities - Estimates are restricted to a conventional plant although project design anticipated the use of pumped storage. Analysis indicates that pumped storage will be a profitable investment which will be made by local utility companies.

08 Roads and Bridges - This item is restricted to roads and bridges at the dam site.

11 Levees and Flood Walls - This item refers to protection work at Matamoras and Port Jervis. An increase in cost over the original estimate occurred due to the need for additional levees on the Port Jervis side of the river.

13 Pumping Stations - These are facilities required in support of the levees.

14 Recreation Facilities - Estimate is based on the largest number of people that could be handled by the projected facilities. The estimated future demand is a far larger number.

16 Bank Stabilization - This is an item to preserve expensive property and structures at Milford which would otherwise be undermined by the reservoir.

19 Buildings, Ground and Utilities - All new construction.

20 Permanent Operating Equipment - Included here are items for hydrologic instrumentation, maintenance vehicles, fixed radio antennas, and foundation instrumentation.

The estimate breakdown is shown in the attached table. It is our judgment that the original estimate, as updated, is a reasonable outgrowth of a thorough and professional study of the proposed project and fairly represents the first cost of TILP through December 31, 1974.

Table 7 - 1. Tocks Island Lake Project Cost Estimate (Dec. 31, 1974)

COST ACCOUNT NO.	ITEM	AMOUNT (Thousands)
01	LAND AND DAMAGES	$ 95,900
02	RELOCATIONS	50,295
03	RESERVOIRS	11,760
04	DAMS	112,665
06	FISH & WILDLIFE FACILITIES	8,375
07	POWER PLANT	33,390
08	ROADS	400
11	LEVEE AND FLOODWALLS	22,470
13	PUMPING STATIONS	7,245
14	RECREATION FACILITIES	27,200
16	BANK STABILIZATION	530
19	BUILDINGS, GROUNDS & UTILITIES	580
20	PERMANENT OPERATING EQUIPMENT	540
30	ENGINEERING AND DESIGN	15,435
31	SUPERVISION AND ADMINISTRATION	13,335
		$ 400,120

VII.D. USE OF THE CONCEPTS OF PROBABILITY AND STATISTICS IN PROJECT FORMULATION, DESIGN AND REVIEW

VII.D.1 INTRODUCTION

The use of concepts of probability and statistics is of considerable importance in project formulation and design. Such concepts provide the basis for long-term allocation of water and establishment of project scale. Because these concepts are so fundamentally important, the use of them by the Corps of Engineers and others concerned with water resources in the basin is reviewed. In addition, review studies of the Tocks Island Project or studies on peripheral matters that relate to the project are reviewed relative to the use of concepts of probability and statistics.

VII.D.2 RELEVANCE OF DROUGHT EVALUATIONS CARRIED OUT TO DATE IN PROJECT PLANNING, DESIGN AND REVIEW

A probability concept of concern to many who have been involved in the planning, design or review of the Tocks Island Project is that of drought recurrence. A good deal of effort on the part of many has been put into defining drought events and then attempting to establish a probability or frequency of occurrence for the drought thus defined. There has been a general tendency to deal with the return interval or frequency of drought in a way similar to the manner in which the return interval for floods are ordinarily specified. This procedure is dangerous because the element of

time (duration of the drought) is an explicit component of drought calculations while it is much less so for floods. The extent of disruption from a flood event is somewhat connected to flood duration but the relationship is not very pronounced. Once a farm or house and its contents is under water, it matters relatively little how long the immersion lasts. The duration issue with drought is notably different. First one has to define a drought in order to meaningfully attach a return interval to it. This specification is necessarily arbitrary or at best project-specific, and consequently the return periods that are established for such an arbitrarily defined drought are tenuous at best.

VII.D.3 REVIEW OF SPECIFIC STUDIES

VII.D.3(a) Report on the Comprehensive Survey of the Delaware River Basin, U.S. Army Corps of Engineers, 1962

The use of concepts of probability and statistics in this document as well as in the design memoranda which detailed the design of the project were confined to evaluation of historic records. No attempt was made to evaluate the return period of drought and drought was not used as a basis for establishing project scale.

Storage requirements for water supply were identified by determining the storage required to supplement natural stream flows. The natural stream flows selected for this determination were those that are exceeded on an average of 95 percent of the time. The basis for selecting these particular flows appears to have resulted from Corps of Engineers' standard practice rather than through drought determinations.

VII.D.3(b) Draft Report of Coordinating Committee for the Reappraisal of Water Supply Resources of the Delaware River Basin and Service Area (67-4 report)DRBC, 1969

Droughts are defined in this report as periods through which precipitation is insufficient to support established human activity. This definition basically avoids the notion of duration; some human activities might be interrupted if precipitation is inadequate over a time period as short as a few days while other activities are measured over months, seasons or even years. Unlike the situation of floods discussed above, it definitely does matter how long an activity is exposed to deficiency in precipitation or flow.

VII.D.3(c) Probability of Analysis of Allowable Yield of New York City Reservoirs in the Delaware River Basin, A Report to the DRBC, by Clayton H. Hardison, U.S. Geological Survey, 1968

We believe that this paper is in the right spirit, but does not fully reflect some technological details. On figure 1 of this document, for example, the contours of equal failure rate, or recurrence interval, employ the percentage of years that a reservoir would become empty. This is in the right direction but the plot would be much more useful if the parameter of failure were more closely tied to a specific time interval. For example, if the reservoirs become empty more than once in a particular year, or if they become empty for a single short time period, or if they become empty once for a protracted period, the economic, environmental and regional consequences are likely to differ significantly. There is no way to determine this from the information presented. Consequently this work could be more useful if it employed an approach not involving the arbitrary definition of the drought event.

VII.D.3(d) <u>Water Resources Study for Power Systems</u>, by Tippets-Abbett-McCarthy-Stratton, 1972

This report is a very useful document, but it also contains arbitrary definitions and generalizations regarding drought-event definition. A drought is classified as a period when the average runoff for one or more years falls below 65 percent of a long-term average. There does not appear to be any justification for the use of 65 percent as a cutoff level for drought. This report, however, does describe the application of a very useful general purpose river basin simulation model (HEC-3), and while historical records were used as a basis for the simulations carried out with it, the report does suggest that synthetic hydrology be used to improve the validity of the results.

VII.D.3(e) "Reappraisal of Water Resources in the Delaware River Basin using Synthetic Hydrology", Yu Shiao and John E. McSparran, *Water Resources Bulletin*, (1971).

This work represents the second application of synthetic hydrology to the Delaware Basin, the first having been made by Hufschmidt and Fiering (1962). This earlier work was primarily concerned with the Lehigh River, although the work was extended to the main stem of the Delaware. While the general approach used by Shiao and McSparran in applying synthetic hydrology is a useful one to follow, we believe that there are at least two fundamental errors in the application. Stations were grouped if they possessed similar correlograms, which is inadequate and perhaps inappropriate, because correlograms for closely related sites may appear to be quite different.

The second major difficulty with the paper is its reliance on the binomial

theorem and approximations thereto. This reliance is inappropriate because the effects of long-term storage, particularly with a large reservoir such as Tocks Island, cannot readily be accommodated by the Bernoulli (or independent) trials on which the binomial theorem depends. It is appropriate to use synthetic hydrology to generate failure probabilities. On the other hand it is totally inappropriate to use these failure probabilities in a binomial expansion. Again, part of the difficulty inheres in the fact that failure at various locations in the system is not defined over the same time horizon, so a more sophisticated mode of presentation is required.

VII.D.3(f) "Operational Hydrology in High-Flow Skimming Using Round Valley Reservoir", Smith Freeman and Werner Schmidt, Chapter 3 in The Tocks Island Dam, a Preliminary Review, Save The Delaware Coalition, Philadelphia, 1973.

A very significant application of synthetic hydrology is described in this reference. Synthetic hydrology was used as input to a simulation model developed to evaluate a flood skimming alternative to the Tocks Island Project. Monthly values of streamflow were generated from historical flow records. Daily flows were obtained from the monthly flows by means of a smoothing procedure. The only difficulty of the development of daily flows on this basis is that it is completely deterministic. The procedure could have been improved if an investigation had been made of the standard deviation of daily flows as a function of the monthly values so that a noise component or random smear could be superimposed on the daily values thus derived.

The procedure also assumes perfect correlation among flows on the Raritan

River, although the spatial correlation between a key gage on the Raritan River and on the Delaware was considered. The validity of this assumption is unclear. Nonetheless, this work represents one of the most significant and successful applications to date of synthetic hydrology to the matter of the evaluation of the Tocks Island Reservoir.

VII.D.4. DEVELOPMENT OF AN IMPROVED APPLICATION OF PROBABILITY CONCEPTS

We believe that definition of the drought event is necessarily an arbitrary exercise. The definition says nothing about the probability of return interval or of the effects of the drought which are really the elements of concern. Consequently, we believe that it is far more important to establish probabilities and return intervals for these effects than for the drought itself. The results of our evaluations with regard to the feasibility of establishing probabilities and return intervals with particular application to the salinity question in the estuary are contained in Section III.E.

VII.D.5. DOWNSTREAM STORM PROBABILITY

The probability of a major storm centering on only that portion of the Delaware River watershed below the Tocks Island site has not been analyzed to date. Cursory examination of historical storm patterns indicate that very few major storms were centered on just that area downstream

from the Tocks Island site and generally these created problems on tributaries such as the Lehigh and Schuylkill Rivers and not on the main stem of the Delaware River itself. Due to the watershed configuration, existing channel capabilities and known historical storms, the probability of generating a major flood in the Delaware River downstream from the Tocks Island site appears to be remote. A detailed analysis of historical storm patterns could be made, possibly by the Hydrometeorological Section of the National Oceanic and Atmospheric Administration (U.S. Weather Bureau), to establish statistical relationships and permit damage estimates and probabilities to be derived.

VIII.A. PLANNING CRITERIA AND PROCEDURES

VIII.A.1. FORMULATION OF DELAWARE RIVER BASIN PLAN

Authorizations for the development of a comprehensive plan of the Delaware River are contained in Resolutions by the U.S. Senate Committee on Public Works. These resolutions are summarized in Appendix "A" of House Document No. 522, and directed that the study of the Delaware River be made in the interest of flood control, navigation, water supply, stream pollution abatement, recreation, fish and wildlife, electric power, feasibility of a barrier in the Delaware estuary and other purposes. Congress directed that the plan for the control and utilizations of the water resources of the Delaware River cover a multiplicity of purposes and that no single purpose was to dominate over any other purpose. Congress also prescribed the comprehensive nature and extent of the planning studies.

It was understood at the beginning that the comprehensive approach to the development of water resources of the Delaware River would be undertaken within the general constraints established by existing laws and policies of the government and would reflect the controls and responsibilities of the various levels of government and established financial procedures. Since the needs for water-related products and services throughout the Delaware River Basin may be related to excesses and deficiencies of surface water supplies, and in areas with recreation potentials a need may exist because of a dearth of developable surface waters at locations favorable

for such recreational activities, measures to impound and regulate the surface waters seem to offer a likely means for satisfying a major portion of the needs for the products of the basin's water resources.

These impoundment and regulatory measures range from various physical features of land management in the uppermost headwater areas, through small detention reservoirs in the intermediate upstream areas, to major impounding reservoirs in the principal water course area. An inventory of major impoundment and development potentials in the basin listed 193 reservoir sites along the main stem and major tributaries of the Delaware River and 386 sites along the intermediate upstream tributaries. From these sites a combination of reservoirs was selected which would satisfy, in a timely manner, the major water-dependent needs of the service area more economically than any other combination. The selected plan consisted of 11 major control projects to be constructed prior to the year 2010; 8 major control projects to be developed for recreation prior to 2010 with water supply to be added later; and 39 small reservoir projects to be developed under continuing authorizations. Of the 11 major control projects:

- All would provide for water supply and recreation.
- Eight would provide for flood control.
- Two would provide for hydroelectric power.

The Tocks Island Reservoir project was one of the 11 major control projects selected and recommended and subsequently authorized for construction by the Flood Control Act of 1962. The authorized purposes of the project were: Flood Control, Water Supply, Recreation, and Conventional Hydroelectric Power. After review of the Survey Report, the Board of Engineers for Rivers and Harbors in their letter to Chief of Engineers dated August 9, 1961 stated that during their review the Federal Water Pollution Control Act Amendments of 1961 (P.L. 87-88, 87 Congress) was approved. Section 10 of this Act amends the Water Supply Act of 1958 and it should be considered as it applies to the projects recommended for authorization.

Since authorization of the project, environmental concerns have become a more important factor for consideration during the planning process in the development of water resources projects. This change in concept together with the amendment of the Water Supply Act of 1958, as cited earlier, has added the purposes of Water Quality Control, Pumped Power, Sport and Commerical Fishing, Wildlife Protection, Preservation of Areas of Natural Beauty, and Preservation of Areas and Items of Historical Importance to those already stated to be analyzed in the re-evaluation of the project formulation for Tocks Island Reservoir.

VIII.A.2 POLICIES, STANDARDS, AND PROCEDURES

The policies, standards and procedures utilized in the formulation and evaluation process for development of Tocks Island Lake Project are contained in the following:

(1) "Delaware River Basin Report" House Document No. 522, 87th Congress, 2nd Session, dated August 16, 1962.

(2) "Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources," Senate Document No. 97, dated May 29, 1962, and Supplement No. 1, "Evaluation Standards for Primary Outdoor Recreation Benefits", dated June 4, 1964.

(3) "Proposed Practice for Economic Analysis of River Basin Projects," dated May 1958.

The criteria used to determine the optimum scope of the project in relation to benefits are:

- Tangible benefits exceed project economic costs.
- Each separable purpose provides benefits at least equal to the cost of including that purpose to the project.
- The scope of development provides the maximum net benefits.
- There is no more economical means, evaluated on a comparable basis, of accomplishing the same purposes which would be precluded from the development if the plan were undertaken.

These criteria are commonly used by Federal Agencies.

VIII.A.2 (a) Period of Analysis and Interest Rate

The period of analysis and interest rate used in the preauthorization

report were 50 years and 2 1/2 percent, respectively. In the Design Memorandum No. 3 the period of analysis used for economic evaluation of the project is 100 years and the interest rate was 3 1/8 percent. This latter interest rate was established in accordance with the regulations issued by the Water Resources Council and published in the Federal Register on December 24, 1968.

VIII.A.2. (b) Construction Period

It was assumed in Design Memorandum No. 3 that construction would be initiated during fiscal year 1971 and be completed during fiscal year 1978, providing a construction period of seven (7) calendar years.

VIII.A.3. ESTABLISHMENT OF THE SCALE OF DEVELOPMENT OF TOCKS ISLAND LAKE PROJECT

The establishment of the scale of Tocks Island project and the resultant allocation of storages to various purposes are dependent on the needs for goods and services produced by the project, the economic analyses (evaluation of benefits and costs) and the constraints and impacts which have a limiting effect on the project. The economic analyses, based on criteria as set forth in Senate Document No. 97, required the determination of benefits and costs for various levels of development.

VIII.A.3 (a) Benefits

The basis for derivation of benefits normally used in Federal agency practice for the various purposes are as follows:

Flood Reduction Benefits - These benefits are computed from four separate components:

a. Original Investment - This component reflects damages experienced as disclosed by a damage survey. These damages are escalated from the time of the survey to the present time using the average of the increases of the "ENGINEERING NEWS-RECORD-BUILDING COST INDEX" and the "BUREAU OF LABOR STATISTICS - CONSUMER PRICE INDEX". This escalation accounts for the inflation of the value of the original investment.

b. Additional Investment - This component reflects the additional investment of physical features in the flood plain since the damage survey. This investment is known as the development component of growth and is a function of existing and proposed land use, and the growth in population. This investment does alter the flood plain usage.

c. Affluence - This component reflects the increase in damageable assets attributable to the increased spending power of the resident of the flood plain in constant dollars, and is related to the rise in personal income. This investment does not alter flood plain usage.

d. Land Enhancement - This component reflects the benefits attributable to the increased or higher utilization of property in the flood plain made possible by the provision of flood protection. The investment associated with the higher use alters the usage of the flood plain. Annual net income values are reconciled with capital or market values by the application of a long-term financing rate of 6 percent.

Water Supply Benefits - The value of benefits from storage of water for water supply is determined by estimating the cost of the least costly, single purpose alternative to be privately constructed and financed, i.e. a privately-financed water supply reservoir created by a dam located at the Tocks Island site.

Recreation Benefits - These benefits are based on a weighted average valve per visitor day. The current estimate of recreation benefits is derived from an evaluation of the recreational demand, the optimum capacity of the project, and unit values in accordance with current criteria and evaluation techniques used by Federal agencies.

Conventional Hydroelectric Power - Power benefits were computed from data furnished by the Federal Power Commission. The value of power was based upon the cost of the least costly alternative source which is a Federally - financed fossil-fuel steam plant.

Water Quality Benefits - Water quality benefits were based on information furnished by the Federal Water Pollution Control Administration. The value of water quality storage required for pollution control downstream was determined from the costs borne by users to produce less saline water.

VIII.A.3. (b) Costs

Annual costs are determined on the basis of interest and amortization of the estimated first cost of the project plus operation, maintenance and major replacement annual costs and the economic cost of land.

VIII.B. REVIEW OF ECONOMIC ANALYSES

VIII.B.1. GENERAL BACKGROUND

The formulation of the size of Tocks Island Lake and the amount of water resource products to be generated were based on an economic analysis of supply and demand for these products in their appropriate service areas. Generally, the process began with the projections of some basic parameters of demand for water supply, flood control, recreation, hydroelectric power and other resource products. These projected parameters included population, households, employment and total personal income. The ready demand for all the outputs of Tocks Island was assumed in lieu of planned alternative sources of supply adequate to meet the large projected demand. Assuming that any and all water resources products would be used, the scale of the project was then determined under the guiding rule that its size be set at the point maximizing the ratio of project benefits to project costs.

The following briefly reviews the adequacy of the basic projection of population, households, employment and total personal income contained in House Document No. 522 in light of trends in these measures since 1955.

The following table shows the projections contained in House Document No. 522 (project document) for the period from 1955 to 1980 for population, households, employment and total personal income. Also listed is the actual data for 1960, 1970 and 1973. The numbers were not recorded for the same time periods. However, it is possible to evaluate them through a comparison of projected and actual annual rates of change for similar although not exactly alike time periods.

Table 8-1 Comparison of Project Document 1955-1980 Projections with Actual Data, Delaware River Service Area

	1955	1960	1965	1970	1973	1980
Population (thousands)						
Project Document	21,589		25,000			30,000
Actual	21,589	23,059		25,763	25,899	
Households (thousands)						
Project Document	6,499		7,400			9,100
Actual	6,499	7,125		8,279	8,628	
Employment						
Project Document	9,073		10,300			12,400
Actual	9,073	9,300		11,020	10,925 3/	
Total Personal Income (billions of 1957 dollars)						
Project Document	53.7		70.0		94.9 3/	100.0
Actual	53.7	61.9 1/		89.1 2/		

1/ 1959 data.
2/ 1969 data.
3/ 1972 data.

Sources: Project Document: House Document No. 522, 87th Congress, 2nd Section; Actual: Population: U. S. Census Bureau, Households: 1960 and 1970 Census, 1973 estimate of Hammer, Siler, George Associates; Employment: U. S. Bureau of Labor Statistics, Department of Labor and State Sources, Total Personal Income, U. S. Department of Commerce, "Survey of Current Business."

Generally, the earlier projections forecast more population and employment and less household and income growth than actually occurred from 1955 to 1973. The projections are reasonably accurate to 1973 but their value for future projections appears to be limited. Recent demographic and economic trends in the region cast some doubt on the validity of projections for 1980 and ensuing years as the area's growth slowed considerably from 1970 to 1973. In contrast, steady growth was projected in the earlier document.

Table 8 - 2 Comparison of Annual Rates of Growth For Selected Projection Periods of Project Document and Experienced Rates of Growth

	Population	Households	Employment	Total Personal Income
1955-1965 (Projected)	1.45%	1.26%	1.23%	2.64%
1955-1970 (Actual)	1.13%	1.58%	1.26%	3.63% 1/
1965-1980 (Projected)	1.18%	1.34%	1.20%	2.36%
1960-1973 (Actual)	0.82%	1.44%	1.30% 2/	3.29% 3/
1955-1980 (Projected)	1.26%	1.30%	1.21%	2.43%
1955-1973 (Actual)	0.97%	1.54%	1.05% 4/	3.17%

1/ 1955-1969
2/ 1960-1972
3/ 1959-1972
4/ 1955-1972

Sources: Project Document: House Document No. 522, 87th Congress, 2nd Section; Actual: Population: U. S. Census Bureau, Households: 1960 and 1970 Census, 1973 estimate of Hammer, Siler, George Associates; Employment: U. S. Bureau of Labor Statistics, Department of Labor and State Sources, Total Personal Income, U. S. Department of Commerce, "Survey of Current Business."

As seen in the above two tables, original projections were high for population and employment and low for households and income. Population grew at an annual rate of 0.97 percent in the 53-county Delaware River Influence Area from 1955 to 1973 compared to a projected 1.26 percent rate from 1955 to 1980; employment growth also lagged behind earlier projections with a projected 1955 to 1980 annual growth rate of 1.21 percent and actual growth of 1.05 percent from 1955 to 1972. Households grew at a pace of 1.54 percent per year compared to a projected rate of 1.30 percent and actual total personal income increases (in 1957 constant dollars) were

3.17 percent per annum in contrast to projected growth of 2.43 percent per year.

Those differences alone would not be sufficient to doubt the validity of earlier forecasts. Combined with recent trends of employment declines, little population and income growth and a declining share of national totals, however, projections contained in the project document appear to be high for 1980 and beyond.

The significance of the differences in the original projections and revised projections is likely to be small in the short run because of the general manner in which demand projections were used in project formulation of Tocks Island Lake. At that time, the demand projections for water supply, flood control, recreation and hydroelectric power far outstripped their foreseeable supply. It is still likely that the water resource products generated by the project will be needed within the service area. However, if the present trend of no-growth or slow growth prevails over the projection period, the original 2010 projections contained in the project document could well be higher than those derived based on recent demographic and economic trends and activity location patterns.

As noted in the initial portion of this "General Backgorund" Section, the benefit and cost allocation analysis for the Tocks Island Project was formulated in Appendix V of House Document No. 522 (Volume XI). This section reviews the procedure by which the Corps of Engineers formulated the Tocks Island Lake Project. The procedures used may or may not be the most applicable but such a detailed criticism is not the purpose of this review.

Tocks Island was considered as one of the eleven major control impoundments and costs and benefits were based on a 50 year economic life with an interest rate of 2-1/2%. All benefits were adjusted to 1959 price levels and reflect the level of physical development in the area for the year 1958. Flood damages were determined on the basis of the 1955 survey following the recrod flood of August, 1955 supplemented by a re-survey in 1958 to update observations relative to changes within the floodplain. Damages and costs were also escalated to January, 1959 price levels.

The total damage figure for the 1955 flood is by no means representative of the average annual damages utilized in evaluation of damages subject to prevention and incorporated in benefit-cost ratio computations. However, the 1955 flood surveys and the subsequent surveys of 1958 did afford the needed point of reference for development of stage-damage curves which could be related to stage-discharge and discharge-frequency curves in order to develop damage-frequency curves from which average

annual damages could be ascertained. Included in this concept of average annual damages was a projection of anticipated floodplain development for the fifty year economic life utilized for the analyses at that time.

Subsequent to the publication of House Document No. 522, in 1962, flood damage surveys were prepared in 1966 for the Corps of Engineers by the J.B. Mellan Company, Inc. to define changes that had occurred within the floodplain and re-evaluate damage potential to then current price levels. This survey utilized the concept of reproduction costs less physical depreciation and made an attempt to consider the factor of obsolescence to arrive at a damage figure more truly related to market value. Flood damage tables were developed covering different types of structures and characterizing quality as average, above average and good, or below average and fair. Flood damage tables associated with this study were developed on the basis of square foot values taking into consideration whether or not a basement was involved and giving consideration to the separate flood reaches so that damage evaluations would more appropriately reflect local price factors. Value judgements were intimately involved in the survey process, and as was pointed out in the resulting report,

> "field work of this nature must be conducted by qualified personnel working realistic market value data rather than from pre-established schedules purporting to be value judgements."

In accordance with Federal regulations and Corps procedure, relative to

authorized projects in the budget cycle, benefit-to-cost ratio calculations are updated annually to reflect changing price levels and conditions. The latest information available is that contained in the document entitled, Supplemental Data Report and Supplemental Information to the Final Environmental Impact Statement - Tocks Island Lake Project dated 1974. Appendix H of this report gives economic analysis of the Tocks Island Lake Project based on price levels prevailing as of July 1, 1973. A discussion of this analysis is given below.

VIII.B.2. REVIEW OF CORPS OF ENGINEERS ANALYSIS

VIII.B.2 (a) Establishment of the 3-1/8 Percent Interest Rate

The 1974 analysis utilizes an interst rate of 3-1/8% for economic evaluation of the project. This is higher than the 2-1/2% rate utilized in the project document, but substantially below the 5-7/8% interest rate currently authorized or the 5-5/8% interest rate that was in use in 1974. However, it is the interest rate that was prescribed pursuant to the provisions of Section 80 of Public Law 93-251 by the Water Resources Council and, consequently, its use by the Corps of Engineers was mandatory and not arbitrarily selected. Section 80(b) stipulates that:

> "In the case of any project authorized before January 3, 1969, if the appropriate non-Federal intersts have, prior to December 31, 1969, given satisfactory assurances to pay the required non-Federal share of project costs, the discount rate to be used in the computation of benefits and costs for such project shall be the rate in effect immediately prior to December 24, 1968,..."

With reference to the proviso of satisfactory assurances to pay the non-Federal share of project costs it should be noted that the assurances relative to water supply storage have been furnished by the Delaware River Basin Commission (Resolution 65-24, 13 September 1965 and Resolution 68-9, 25 September 1968). Assurances relative to encroachment on the downstream channels are not required for a navigable waterway under the jurisdiction of the Corps of Engineers. These assurances have been considered adequate with respect to the above quoted proviso from Section 80 so that freezing the discount rate at 3-1/8% is considered appropriate.

VIII.B.2 (b) Comparison of the 3-1/8% Percent and Current Interest Rates

The use of a 3-1/8% interest rate has been criticized by some as unrealistic and, therefore, an analysis has been made for the purpose of this review based on the use of a 5-7/8% interest rate to determine the impact on benefit-cost ratios. The change from a fifty year to a one hundred year economic life has relatively small impact on project justification, but a change in interest rate can have a significant impact and it has been considered appropriate to explore the sensitivity of project justification to this change. Higher interest rates, of course, result in lower project benefits where future benefits throughout the project life are being reduced to present worth or average annual values. At the same time, these higher rates result in higher average annual costs. Consequently, the B/C ratio is forced downwards by both reduced average annual

benefits and increased average annual costs. Another consideration that must be incorporated into an evaluation of impact of varying interest rates is the differential that exists between applicable rates of federal and private financing. This is because private financing rates are considered in the cost allocation process and have an effect on benefits credited to various project purposes. Any distortion of rates between federal and private financing introduces a distortion in the economic evaluation process. However, the test referred to above, based on utilization of higher federal rates by the Corps of Engineers, is conservative and insures that such potential distortion does not imply greater benefits than can be properly credited to the project.

The results of the above analysis show all project purposes have a benefit-cost ratio greater than unity. When recreation was limited to 4,000,000 visitors annually and the value of $1.35 per visitor day (H.D.522) used, the B/C ratio dropped slightly below unity. However, the current (1975) regulations provide an increase in value per visitor day which, when applied to the project recreation benefits, exceed unity as stated above.

VIII.B.3. ANNUAL COSTS

The average annual cost of the project as of 1 July 1973 has been calculated at $15,860,000 based on a first cost of $360,575,000 and

interest during construction of $39,437,890 for a total of $400,012,890. Resulting Average annual costs are summarized below:

Average Annual Costs:

a.	Interest and Amortization = $400,012,890 x .03276	=	$13,104,422
b.	Operations and Maintenance	=	1,758,000
c.	Major Replacements	=	353,000
d.	Economic Cost of Land	=	645,000
	TOTAL	=	$15,860,422

Rounded to $15,860,000

VIII.B.3(a) Comparison of Restricted and Full Recreation Development

In addition to the above, the average annual cost for future recreation development has been calculated at $2,429,000, assuming full development of the recreation potential within a ten year period to accomodate 9,386,000 visitor days per year. This 10-year period is reasonable from a facility development and demand growth viewpoint. However, considering the regional infrastructure needed to support this growth comfortably, including transportation development, the 10-year period may be questioned. This assumed period could be varied; however, the impact of reasonable variation would be insignificant. This results in a total average annual cost of $18,289,000 with full recreation development versus the lesser figure of $15,860,000 average annual cost, assuming recreation is limited to 4,000,000 visitor days per year. This 4,000,000 visitor day limit has been accepted by the Delaware River Basin Commission.

Appendix H of the 1974 Supplemental Data Report referenced above also itemizes average annual benefits as follows:

Recreation (full development)	=	$ 11,708,000
Power	=	3,230,000
Water Supply	=	10,236,000
Flood Reduction	=	3,824,000
		$ 28,998,000

Recreation (4,000,000 visitors annually)	=	$ 5,153,000
Power	=	3,230,000
Water Supply	=	10,236,000
Flood Reduction	=	3,824,000
		$ 22,443,000

The benefit to cost ratio, based on the above, has been calculated as 1.8 for full recreation development and 1.4 with restricted recreation development. This compares with a benefit-cost ratio of 2.2 as stipulated in House Document 522 (Table H-13) based on total annual project benefits of $17,100,000 and total annual economic cost of $7,700,000. Under conditions of full recreation development it is obvious, from the above table, that recreation is one of the primary sources of project benefits, affording over three times the benefit attributed to flood reduction and approximately 14% more benefit than that associated with water supply. Under the computation, based on 4,000,000 visitors annually, the benefit associated with recreation is reduced considerably but still exceeds that associated with flood reduction by approximately 35% and is equal to about 50% of that associated with water supply. These benefit figures have been derived on the basis of $1.35 per visitor day in accordance with supplement No. 1

of Senate Document No. 97 which stipulated a range of from 50¢ to $1.50 per day. The $1.35 figure selected within this range was based on judgment predicated on the quality of the proposed development and the facilities provided and is not subject to escalation with cost of living increases. It is, however, worthy of note that the current regulations (1975) specified the value of a visitor day as being 50% over the range stipulated in supplement No. 1 of Senate Document No. 97, so that projects under current investigation would be assessed at somewhere between 75¢ and $2.25 per visitor day. The value of visitor day used, while it is a rather arbitrary value, is certainly not an excessive quantity and is considered to be quite conservative.

VIII.B.4 ANNUAL BENEFITS

VIII.B.4 (a) Recreation Benefits

Recreation as a project purpose is translated into a tangible benefit by the application of admittedly somewhat arbitrary dollar values for a visitor day. There is room for considerable philosophical difference among different interest groups as to what might be considered an appropriate measure for evaluation of recreation benefits, but it should be recognized that except for the application of limited judgment, within the stipulated range designated by the Congress, with due consideration to the calibre of recreation being furnished, there is relatively little latitude which can be exercised by the Corps in

evaluation of these benefits.

VIII.B.4 (b) Water Supply Benefits

Water supply benefits have been computed based on the cost of the most feasible alternative source of water supply equivalent to that available from Tocks Island. For this purpose, an impoundment at Wallpack Bend and a sub-impoundment at Flatbrook were utilized assuming private financing at a 4-1/2% interest rate. On the basis of this equivalent water supply project, benefits were calculated at $10,236,000. The principle of cheapest alternative source, based on private financing, has long been an accepted Government procedure in evaluating water supply benefits. The use of a 4-1/2% rate in this case results in benefits attributable to water supply which are considerably less than would result if a higher rate were utilized, such as 6%. It is not intended to suggest here that the 4-1/2% rate utilized was too low, but only to point out that given a high rate the resulting evaluation of benefits would be higher. It would appear that the economic evaluation of water supply benefits has been conservatively treated assuming that there is a need for the full water supply to be developed by the Tocks Island Project. The Philadelphia office of the Corps of Engineers has indicated that the current evaluation of needs is based on the latest OBERS Series E Projections which are considerably more conservative than those in use at the time of project formulation. It has also been indicated that the water supply storage allocation was limited by physical constraints on project size (with

the impact on ground water table as one of the limiting conditions) rather than being limited by projected demand.

VIII.B.4 (c) Flood Reduction Benefits

General--

Flood reduction benefits have been computed on the basis of damage surveys immediately following the 1955 flood, supplemented by subsequent surveys in 1958 and 1966 to evaluate changes in floodplain conditions and update damage estimates. The procedures, as utilized in House Document No. 522 in which average annual damages were determined through utilization of damage frequency curves, are all in accordance with what would be expected of a normal prudent individual, and the reliability of the damage estimates to be anticipated under future conditions has been increased by virtue of the updating surveys of 1958 and 1966. However, it must be recognized that a considerable aspect of approximation is involved. The average 1955 damages were obtained principally from field interviews. This technique is subject to obvious potential distortions on the part of those interviewed and to errors of judgment on the part of those performing the interviews. While sampling techniques were utilized to control such distortions, it must be recognized that the results of such surveys, however carefully pursued, can result in error in either direction.

Business Loss and Emergency Cost Adjustment--

Another aspect of approximation relates to the element of business loss and emergency cost adjustments as discussed in Paragraph 34 of Appendix D of House Document No. 522. As pointed out, in the above reference, a percentage relationship of business loss and emergency cost to actual physical damage was utilized. The Corps concluded that, "The 1955 Flood damage loss in the Basin is not significantly altered by using the percentage method of deriving business losses and emergency costs." Most elements of flood damage reflected in computations of average annual damage are caused by floods of significantly lesser proportion than that of the record flood of 1955. In order to evaluate recurring damages for these floods of lesser stage but higher frequency, empirical relationships were developed relating damage to stage. These relationships were tested against damages experienced on the Lehigh River and the results found to be reasonable, but once again an aspect of approximation exists which is difficult to circumvent. This technique of vertical distribution of damages was carried out in even greater detail through the use of flood damage tables as developed in the 1966 survey.

Future Development--

Average annual flood damage estimates also incorporated consideration of increased potential damages throughout project life based on future development in the floodplain. The technique utilized, in the project document, in evaluating trends of development in the floodplain,

was to measure changes in land use from non-urban to urban based on comparison of aerial mosiacs in 1938 and 1958. Projections were then based on straight line extrapolation of the historical trend as interpreted from these photographs. With reference to the interpretation of photographs it should be noted (Paragraph 58 Appendix D House Document No. 522) that, "Due to the relative narrowness of the flood plains . . . and the scale of the photographic mosaics, the delineation of the floodplain proper . . . did not embrace areas of sufficient magnitude to permit interpretation. By widening the areas delineated . . . to include not only the floodplain area, but also areas immediately adjacent to it, it was possible to undertake a meaningful area photograph analysis . . . " The assumption that the historical trends can be extrapolated into the future and, further, that the development within the floodplain is generally similar to that in the immediate adjacent areas must both be viewed with reservation. The conclusion reached by the Corps (Paragraph No. 60 Appendix D) was that, "For the Delaware River, urban floodplain growth will increase from 37% in 1958 to 48% by 2010."

In the evaluation of average annual damages, consideration was given to projected growth within the floodplain, as indicated above. It was also assumed that future additional development would be affected by stage in the same fashion as existing development as determined in the 1958 surveys and subsequently re-evaluated in the 1966 surveys. Thus, the project document indicates that the projected 1980 damage

potential is 13% greater than the 1958 potential and the 2010 potential is 32% greater than that calculated for 1958.

Enhancement--

Land enhancement benefits attributable to higher utilization of property are considered valid flood control benefits. However, the difficulties generally associated with the evaluation of this benefit is to properly assess the dollar value utilized. These difficulties relate to projection of capital market values associated with anticipated land uses. While the prospect of enhancement is very real, the specific uses of flood plain areas is highly speculative so that net income values to be anticipated are equally difficult to assess. Additionally, it should be noted that construction of housing in areas below the Tocks Island Dam which were formerly classified as floodplain, can be dangerous since the dam is not designed to completely eliminate all future flooding below it. Among the reasons for this difficulty in assessing future net income values are the impact of floodplain zoning regulations and the associated problems of financing for development work within the floodplain areas. Furthermore, even when specific plans for development are being contemplated by a given industry, the studies preceding decision usually entail consideration of possibly 10 or 15 alternative sites which are studied in great detail by a team of experts over a period of possibly six months to two years. Any attempt to outguess the conclusions from such studies, especially as relates to a wide variety of potential users of floodplain properties,

is bound to be beyond the reasonable scope of any feasibility study, such as House Document No. 522. Because of this problem, the method of evaluation of this component is not felt to be the preferred method. An alternative method would be to utilize the estimate of future damages that would be prevented under anticipated conditions of floodplain development based on approximations, such as comparison with another developed area, as a measure of benefits rather than to attempt to relate this measurement to annual net income based on higher utilization of property. These comments are offered as observations on methodology and to emphasize the aspects of approximation involved in either procedure while at the same time acknowledging the validity of the concept. In view of the methodology mandated, the studies and conclusions reached by the Corps of Engineers are considered to be adequate and satisfactory relative to the component of land enhancement.

Summary of Flood Reduction Benefits--

Since the House Document 522 concerned itself with development within the Basin as a whole, and utilized the 1955 flood damages as the primary point of reference for determining average annual damages, it is interesting to note the evolution of damage estimates form this initial study.

1955 FLOOD DAMAGES

Total Damages at 1958 price levels	$123,500,000
Recurring Damages (Approx. 70%)	$ 86,725,200

Average Annual Damages:

At 1959 Price Levels	$ 9,223,900
Eliminated by existing flood control measures and those under construction	$ 3,126,000
Net Average Annual Damage (Entire Basin)	$ 6,097,900
Net Damages Considering Mainstem of Delaware River only	$ 2,559,400
Net Damages on Mainstem below Tocks Island	$ 2,181,400

The flood reduction benefits, recomputed as of 1 July 1973 based on consideration of inflation and additional investment, indicates an initial benefit of $2,855,859. To this has been added a factor to reflect growth and affluence based on 2.18% per year for the eight year period from 1965 to 1973 amounting to $537,758 in the initial benefit year.

A further benefit based on land enhancement has been added in the amount of $123,880 per year and this factor has been kept constant throughout the projected one hundred year economic life of the project. The total annual benefits as calculated to July 1, 1973 are, therefore, $3,517,497 in the initial benefit year. The benefits as calculated in the initial year were then increased through the 50th year and held constant thereafter to reflect additional investment in the floodplain

anticipated on the Pennsylvania side. No parallel increase was considered on the New Jersey side in view of the floodplain zoning act which restricts additional investment in the floodplain. A similar projection of the affluence factor to the 50th year was also included resulting in total annual benefits between the 50th and 100th year of $4,136,148. Based on these two figures, the average annual benefits over the life of the project were computed at $3,824,000. This figure compares with the average annual damage figure of $2,181,400 given above based on the project document.

In attempting to assess the reasonableness of the above estimate of average annual benefits, it is necessary to consider the four components of flood reduction benefits individually. These include original investment, additional investment, affluence, and land enhancement. With reference to original investment it must be assumed that the damage surveys of 1955 and the re-surveys of 1958 and 1966 represent the maximum reasonable effort and most reliable practical technique for evaluating this factor. The determination of average annual damages, based on utilization of damage frequency curves and escalation factors, developed as in the above discussions, is considered appropriate. However, it must also be recognized that approximations and potential for error (in either direction) exist, particularly with respect to those considerations discussed, heretofore. After making this reservation, however, it would be difficult to fault the Corps' conclusions on estimates of original investments and

associated damage potential, based on the Corps' mandated methodology.

The item of additional investments appears high and somewhat overstated with respect to the Pennsylvania side. At the same time, it should be noted that no allowance has been made for this item on the New Jersey side in view of the recent floodplain zoning action.

With reference to the adjustment for affluence, the intital correction of 18.83% or $537,758 has been increased by the 50th year to $635,791 and maintained constant thereafter. This item is considered somewhat questionable but at the same time it must be conceded that its inclusion is not without some merit. The difficulty lies in the assumption that increase in damageable assets can be equated to 65% of the change in per capita income. This may well be true with reference to inidvidual families for the duration of their stay within a given floodplain residence. However, consideration of this factor in itself, without recognition of the offsetting factor that families with steadily increasing affluence tend to move on and are replaced by less affluent families, would seem to be questionable.

The total impact of the items of additional investment, affluence, and land enhancement on computation of average annual benefits represent an increase of only 8.7% over benefits calculated for the initial year of project operation - i.e., $3,517,497 x 1.087 = $3,824,000 (rounded). This increase in average annual benefits over the project

economic life is compared with the initial year of operation is relatively nominal and it is not felt that any reasonable modifications to calculations, which might be made in keeping with some of the above discussion, would have any significant impact on computation of benefit cost ratios. This observation assumes acceptance of the initial project year benefits ($3,517,497) and in effect states that given this initial project benefit, the computation of average annual benefits over the project life must be considered reasonable. However, it should also be noted that the initial year of project benefits includes the above referenced item of $537,758 associated with growth and affluence, between 1965 and 1973. This item represents 15.3% of the initial year benefits ($3,517,497) and to the extent that this item is deemed questionable, the impact on the benefit cost ratios would be directly proportional.

Based on the above considerations the project would appear to be economically justified in spite of detailed exceptions to procedure that might be taken by one analyst as opposed to another.

Those differences in viewpoint which have been expressed above do not appear to have sufficient impact on benefit-cost (B/C) ratios as to warrant re-analysis. The basic consideration in economic justification should simply be that each of the separate project purposes is incrementally justified and that each has a B/C ratio of 1.0 or higher. Re-evaluation on a year-by-year basis is standard procedure for

authorized projects that keep estimates current relative to price changes and floodplain developments. Re-evaluation for purposes beyond this should only be considered in a detailed sense if the sensitivity is such that B/C ratios could be reasonably expected to slip below unity.

VIII.B.4 (d) Power Benefits

Benefits associated with conventional power at Tocks Island are based on the cost of providing equivalent energy and capacity with conventional steam electric facilities. Values as utilized in the project document, (See Appendix F, Page 39) were as follows:

> Capacity values \$28.00 per KW per year. Energy values 3.2 mils per KWH. The taxes foregone \$10.15 per KW.

Power benefits are escalated annually and benefits are revised based on average annual cost as furnished by the Federal Power Commission. The latest update of benefit calculations was based on 1974 data furnished by the Federal Power Commission as follows:

a.	Dependable Capacity	-	38,000 KW		\$ 24.00		\$ 912,000
b.	Interruptible Capacity	-	32,000 KW	@	\$ 12.00		384,000
c.	Energy Value	-	307,000,000 KWH	@	\$ 0.0063	=	1,934,100
	TOTAL AVERAGE ANNUAL BENEFITS					=	\$ 3,230,100
	Round To						\$ 3,230,000

It will be noted from the above that the greatest value associated with this installation refers to the energy, which has been stipulated at 6.3 mils per KWH for an average annual energy benefit of \$1,934,000 out of the total of \$3,230,000.

Recent trends within the past year have seen fuel costs escalate as much as 300% resulting in a greatly increased value for energy. This consideration alone makes it obvious that the benefits claimed by power in connection with computation of benefit to a cost ratio, as discussed herein, must be recognized as being extremely low.

Capacity values are also conservative but have relatively little impact by comparison with the energy value. By the same token, consideration of the impact of interest rate utilized and other marginal considerations involved in the detailed analysis does not seem worth belaboring since the conclusion is so obvious that the value of energy greatly outweighs all other considerations and the power purpose of this project is clearly justified when analyzed by the methods mandated by Congress.

VIII.B.5 ECONOMIC JUSTIFICATION

Economic justification must presumably exist before Congress will appropriate funds for construction. The procedure utilized in economic justification, while admittedly allowing a wide area of latitude in the exercise of judgment and the use of approximation techniques, as discussed above, is relatively mechanical and fixed. In many senses, economic justification does not deal in any quantitative fashion with the range of benefits considered in connection with project formulation. By the same token, there are many non-economic costs which are pointed out by environmental groups and others concerned about negative project impacts which are not considered. Concepts proposing non-structural alternatives to flood control (such as flood plain zoning) versus the structural alternative presented by the Tocks Island Project open up a wide area of analysis in which conclusions can not be based on numerical evaluations alone. These alternatives are treated in other chapters of this report and it is the limited intent of this chapter to address the economic analysis as utilized by the Corps for the Tocks Island Project.

VIII.B.6 CONCLUSIONS

Within the frame of reference discussed above, it is concluded the project was properly considered and economically justified in accordance with existing regulations,policies,and procedures.

VIII.C. REVIEW OF CONSTRAINTS AND IMPACTS

VIII.C.1. PHYSICAL CONTRAINTS AND IMPACTS

Limitation on potential locations of the dam are limited due to storage required, foundation conditions, local damage centers and possible affects thereon, recreation needs and geology of the reservoir area.

The Site Selection Design Memorandum No. 1 eliminated sites at Delaware Water Gap because of extensive relocation requirements and protective works required at Stroudsburg. Also, the site at Wallpack Bend was eliminated because of inadequate storage to meet anticipated needs. Foundation conditions and construction costs analysis indicated the selected site just downstream of the southern tip of Tocks Island was the most feasible.

Storage limitations reflect the Delaware River Basin Commission views that 425,600 acre feet would meet foreseeable needs and be required to provide a dependable yield of 2790 c.f.s. The maximum reservoir storage is limited by maximum practical height of protective works required at Port Jervis and Matamoras at the upper end of the reservoir, as well as the fact that ground water table elevations and permeability characteristics of deep soil deposits in this area preclude long term storage of water above approximate elevation 416.

The above constraints on project site and storage allocations limit the scope of the project and preclude inclusion of additional storage for other purposes such as water quality control, additional hydropower, increased water-oriented recreation and associated uses and diversion out of the basin.

VIII.C.2 ECONOMIC CONSTRAINTS AND IMPACTS

Project formulation constraints and impacts on the economic analyses of the Tocks Island Lake project deal primarily with the benefit-cost methodology utilized by the Corps of Engineers. The constraints and impacts of this methodology are analyzed in the balance of this section which contains three parts: 1) background and policy overview; 2) overall constraints and impacts imposed by implementation of adopted federal policies and standards; and 3) constraints and impacts on project purposes.

VIII.C.2(a) Background and Policy Overview

The methodology used by the Corps of Engineers in carrying out its benefit-cost analysis had its origins in the work of the Sub-committee on Benefits and Costs of the Federal Inter-Agency River Basin Committee which began in 1946. In 1950, the Committee adopted a sub-committee report that set forth specific principles and procedures for determining benefits and costs of Water Resource projects to be used by the seven participating federal agencies. The report was revised and reissued in May of 1958 under the title of Proposed Practices for Economic Analysis of River Basin Projects, by the Sub-committee on Evaluation Standards of the Interagency Committee on Water Resources. This report, popularly referred to as the "Greenbook" was the officially adopted policy document under which the Tocks Island Lake Project was originally formulated.

On May 15, 1962, the President's Water Resources Council prepared and recommended a revised policy document titled Policies, Standards and Procedures in The Formulation, Evaluation, and Review of Plans For Use and Development of Water and Related Land Resources. Adopted as "Senate Document 97" and approved by the President, this then became "the bible of benefit-cost analysis" for the Corps of Engineers in carrying out its economic analysis of the Tocks Island Lake Project. On June 4, 1964, the Water Resources Council produced Supplement Number 1 to Senate Document 97 titled "Evaluation Standards For Primary Outdoor Recreation Benefits". These two documents, Senate Document 97 and Supplement No. 1, have been, and are, the controlling policy documents used by the Corps of Engineers in the benefit-cost analysis for project formulation and for continuing evaluation of the Tocks Island Lake project.

On October 25, 1974, the Water Resources Council adopted a new policy document titled Water and Related Land Resources: Establishment of Principles and Standards for Planning. This new policy document which builds on the policies and methods of Senate Document 97 and Supplement No. 1, does not apply to the current evaluation of the Tocks Island Lake project which was authorized by Congress in 1961, prior to the conformance date set by the Water Resources Council.

For purposes of this analysis, Senate Document 97 and Supplement No. 1 have been reviewed in detail to determine the constraints and impacts placed on the Tocks Island Lake project formulation. Specific constraints

were identified from evaluation of the benefit-cost analysis conducted by the Corps of Engineers and articulated in House Document 522, Delaware River Basin, New York, New Jersey, Pennsylvania and Delaware, Volume I (Main Report), Chapter VIII "Physical Effects and Economics of the Plan", and Volume XI, Appendix V, "Benefits and Cost Allocations". Because of the impact of Senate Document 97 and Supplement No. 1 on the Corps of Engineers benefit-cost analysis and subsequent project authorization by Congress, these two important documents are briefly summarized in the paragraphs which follow.

Senate Document No. 97, Policies, Standards and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, had its genesis in an October 1961 memorandum from President Kennedy to the Secretaries of the Departments of the Army, H.E.W., Agriculture and the Interior in which he cited the need for "an up-to-date set of uniform standards for the formulation and evaluation of water resources projects". The resultant document was approved by the President on May 15, 1962.

The stated purpose of this document was "to establish Executive policies, standards, and procedures for uniform application in the formulation, evaluation and review of comprehensive river basin plans and individual project plans for use and development of water and related land resources". In essence, it was to serve as the technical encyclopedia for the benefit-cost analysis of water and related land development projects such as Tocks Island.

Although the basic objective of the planning which this document mandates is the provision of the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs, it states that secondary objectives should also be considered. When the primary objectives -- development, preservation, and well-being of people -- are in conflict, reasoned choices should be made between them.

Ironically, there may not be as much conflict among objectives as there is within them. This is particularly true when consideration is given the multiple-purpose objectives listed under the broad concept of development. These objectives, which are to be provided concurrently, include:

1. Adequate supplies of surface and ground waters of suitable quality
2. Water quality facilities and controls
3. Water navigation facilities
4. Hydroelectric power
5. Flood control or prevention measures
6. Land stabilization measures
7. Drainage measures
8. Watershed management and protection measures
9. Outdoor recreational and fish and wildlife opportunities

Because these objectives may be, and often are, inherently in conflict, the decision-maker's set of values used in weighting each of the purposes becomes a key variable in defining the objective function to be maximized. This in effect adds increased subjectivity to an objective process.

When planning resource use and development, the national viewpoint should serve as a framework in which regional, state, and local viewpoints can be considered. The national viewpoint should be paramount and any significant departures from it to accomplish objectives on a smaller scale must be presented through appropriate planning reports. <u>All viewpoints must consider the relationship of goods and services to be provided to the appropriate requirements and objectives in terms of national economic efficiency</u>.

Within the framework described above, multiple purpose planning, formulation and evaluation may be done comprehensively on the river basin level or on individual project basis. When individual projects are chosen for evaluation, their reason-for-being must be justified on the basis of their relationship with probable later developments in the basin. Regardless of the level on which the project is evaluated and formulated, it must be done on a coordinated basis with other federal agencies and in compliance with the stated purpose; law, legislative intent and Executive policies and orders; recognized technical standards; and standards for the formulation of plans and evaluation of tangible and intangible effects.

Although this formulation and evaluation of plans is normally based on the expectation of an expanding national economy, allowance has been made for conditions for (a) less than "full employment" nationally, and (b) chronic and persistent unemployment or underemployment in designated areas. Standards appropriate to (a) -- the situation in which we now find

ourselves -- shall be those adopted at the time of the existence of such condition and authorized by the President.

Project effects are to be evaluated from a comprehensive public viewpoint which includes a consideration of all effects, beneficial and adverse, short-range and long-range, tangible and intangible, that may be expected to accrue to all persons within the zone of influence of the proposed resource use or development. When this evaluation results in major differences among technically possible plans conceived as either maximizing benefits or optimizing benefits, alternative projects or combinations of projects shall be planned. Basically, this requires that the final project exhibit the best mix of tangible and intangible benefits and primary and secondary benefits.

Evaluation of such projects should include intensive and extensive analysis of the present and future economic conditions in the project area and the function of the proposed project in meeting stated objectives. Essential information should be provided for identifying both immediate and long-range needs in a form useful for program formulation. Presentations in reports should identify: 1) the relationship between economic development needs and opportunities and potential water and related land resource use and development; 2) the economic and social consequences of complete or partial failure to satisfy these needs; and 3) the possible improvements in economic efficiency, alleviation of unemployment, stabilization of production and income, community well-being, and

that quality of goods and services (i.e., recreation) that will be forthcoming.

In the formulation and evaluation of projects, benefits and costs should be expressed in comparable quantitative economic terms -- a criterion which the dollar unit of measure adequately fills. Once the unit of measurement is chosen, the objective function of benefit-cost analysis becomes subject to the following criteria:

1. Tangible benefits exceed project economic costs;
2. Each separable unit or purpose provides benefits at least equal to its cost;
3. The scope of development is such as to provide the maximum net benefits; and
4. There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This limitation refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the project is undertaken.

The objective function (expressed as net benefits) is maximized when the scope of development is extended to the point where the benefits added by the last increment of scale are equal to the costs of adding that increment of scale. This rule is firmly based in classic economics and its marginality principles -- concepts worthy of some basic understanding by the analyst.

__Benefits__ are defined as increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. Benefits include tangibles and intangibles and may be classed as primary or secondary.

Primary benefits are defined as the net value of the goods or services directly resulting from a project, less associated costs incurred in realization of the benefits and any induced costs not included in project costs. Primary benefits include:

1. Domestic, municipal, and industrial water supply benefits
2. Irrigation benefits
3. Water quality control benefits
4. Navigation benefits
5. Electric power benefits
6. Flood control and prevention benefits
7. Land stabilization benefits
8. Drainage benefits
9. Recreation benefits
10. Fish and wildlife benefits
11. Other benefits.

Detailed standards for the measurement of these benefits are presented in paragraphs V-E-1 to V-E-11 in Senate Document 97.

Before net benefits can be assessed, some measurement of costs is necessary. Project economic costs are the sum of installation costs, OMR (operation, maintenance and replacement) costs, induced costs, and associated costs. Taxes foregone or allowances in lieu of taxes are not included in project economic costs.

Once the costs and benefits have been identified, three important considerations enter into the final analysis. These considerations can serve as the fulcrum to tip the scales in either direction -- toward acceptance or rejection of the project. These considerations are the period of analysis, (the shorter of the physical or economic life of the project), the discount rate and the choice of price levels. With two of these considerations being very time-sensitive (the discount rate and price levels), the proper choice of standards is critical and it is here that Senate Document 97 places specific constraints on project formulation. Each of these considerations will be discussed in more detail in Section VIII.C.2(b).

Whereas Senate Document No. 97 is a statement of the general principles to be applied in a multi-purpose benefit-cost analysis of water and related land resources development, Supplement No. 1 deals with evaluation of a specific purpose -- outdoor recreation. Supplement No. 1 is a direct result of a call by President Kennedy to develop specific standards for the measurement of recreation and fish and wildlife benefits. The supplement was passed into law on June 4, 1964.

The purpose of this supplement is to provide standards for the evaluation of recreation benefits from the use of recreation resources provided by water and related land development projects. This purpose must be evaluated in light of the fact that recreation produces an economic product, in the sense that a recreation opportunity is something which has value and for which people will pay.

The standard unit of measurement for the determination of primary outdoor recreation benefits is the recreation day -- a unit consisting of a visit by one individual to a recreation development or area for recreation purposes during any reasonable portion or all of a 24-hour period. Estimates of the pattern of total annual recreation days will generally require estimates of use during the initial development period and at optimum carrying capacity as is the case with the Tocks Island Lake project.

Important factors affecting the extent of total recreation use are: 1) population within the zone of project influence; 2) proximity of the project to centers of population; 3) socio-economic characteristics of the population including disposable income, age, and mobility; 4) leisure-time and recreational habits that reflect changing consumer perferences; 5) the recreation use potential of the project area as reflected by its ability to provide for uniqueness, diversity, and access; and 6) the availability and attractiveness of existing and potential alternative recreational opportunities.

Supplement No. 1 takes Senate Document 97, paragraph V-E-9 a step further by providing a specific schedule of monetary unit values to be applied to tangible benefits. For general outdoor recreation days -- primarily those activities attractive to the majority of outdoor recreationists and which generally require the development and maintenance of convenient access and adequate facilities (i.e., swimming and picnicking) -- unit day values range from $.50-$1.50. Activities of a more specialized nature (i.e., white-water canoeing) are assigned unit day values in the $2-$6 range. In the absence of well-established market figures, these unit values are based on simulated market prices which are intended to measure the amount users should be willing to pay, if such payment were required, to avail themselves of the project recreation resources.

Since these unit values are considered net of all associated costs, they are considered comparable with benefits for other project purposes. In selecting specific unit values both primary and secondary criteria are used. Primary criteria reflect those considerations largely dependent upon project development and management and are often associated with the character and intensity of use. Secondary criteria are those environmental characteristics that are not frequently dependent upon project development and management. Such secondary criteria are subject to the values of the analyst as expressed in the weighting that he assigns them (i.e., weight given on the amount of esthetic satisfaction). The total monetary recreation benefits for a project are determined by applying the

selected unit values to the estimated patterns of annual use over the life of the project, appropriately discounted to a common time base.

In comparing Document No. 97 and Supplement No. 1, the most pertinent observation relates to the nature of each document. As stated earlier No. 97 is general and multi-purpose oriented while Supplement No. 1 is specific and single-purpose oriented. This specificity tends to further define the parameters within which the formulation and evaluation of recreation projects takes place.

The major changes introduced by Supplement No. 1 relate to the refinement of terms. In addition to specific project and time variables being defined, discreet monetary values have been assigned for the measurement of tangible benefits, criteria for establishing specific values in each range have been specified, criteria have been formulated for the evaluation of alternatives and criteria have been established for the consideration of intangible recreation project benefits. In effect, Supplement No. 1 has provided the specific criteria for formulating and evaluating a single project purpose, recreation, within the overall benefit-cost framework outlined in Senate Document No. 97.

From May 1962 to October 1973, the benefit-cost analysis has been under the rules set forth in Senate Document 97 and Supplement No. 1. With the adoption of the "principles and standards" of the Water Resources Council (WRC) on October 23, 1973, the rules have changed. An expressed concern

of opponents to the Tocks Island Lake project relates to whether the WRC principles and standards will be applied to the project for purposes of current evaluation. The Corps of Engineers, as authorized legally under the principles and standards, has opted not to use this new standard, except for purposes of selective sensitivity testing since it was not required to do so. The Corps' reason for "grandfathering" the TILP is that to meet the test of the principles and standards would require a complete new project formulation plan and reauthorization by Congress, all of which would require extensive delays to a project that is now over 15 years in the making. In addition, operational procedures for utilizing the principles and standards have not been issued.

In July of 1974 the Corps conducted a series of sensitivity tests on the TILP benefit-cost ratio (BCR) utilizing the following variables:

- Interest rates of 3-1/8 and 5-7/8 percent.
- Annual visitor days of 4.0 and 9.6 million.
- Recreation benefits computed at $1.35 and $2.03 per visitor day.
- Conventional and pumped storage power generation.

Utilizing the above variables in alternative combinations the Corps conducted a total of 12 sensitivity tests of the TILP benefit-cost ratio, as shown in Table 8-3, following. The tests provided a positive BCR in all cases except one -- number 10 -- which had a negative BCR of .99. Test number 2 is the basic Corps TILP analysis and test number 11 provides the greatest variation from the basic analysis. Both tests result in a positive 1.4 BCR which directly reflects the impact of increasing the key variables of interest rate and recreation benefits which offset each other.

Table 8-3 Tocks Island Benefit-Cost Ratio Sensitivity Alternatives, July 1974

Variables	1	2	3	4	5	6	7	8	9	10	11	12
Interest Rates	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	3 1/8	5 7/8	5 7/8	5 7/8	5 7/8
Annual Visitor Days	9.6m 4/	4.0m	9.6m	4.0m	9.6m	4.0m	9.6m	4.0m	9.6m	4.0m	9.6m 4/	4.0m
Recreation Benefits	$1.35	$1.35	$2.03	$2.03	$1.35	$1.35	$2.03	$2.03	$2.03	$2.03	$2.03	$2.03
Power	conv.	conv.	conv.	conv.	pumped	pumped	pumped	pumped	conv.	conv.	pumped	pumped
Benefit-Cost Ratio	1.6	1.4	1.9	1.6	1.5	1.5	1.7	1.5	1.2	.99	1.4	1.4

1/ Variables

Interest Rate -- 3/ 1/8 or 5 7/8 percent.
Annual Visitor Days -- 4.0 or 9.6 million visitor days annually.
Recreation Benefits -- $1.35 or $2.03 per daily visit.
Power -- Conventional or pumped storage.

2/ Corps basic analysis.
3/ Maximum variation from basic analysis.
4/ Assumes cost of providing added capacity is equal to increased benefits.

Source: Appendix H, "Economic Analysis of the Tocks Island Lake Project," Supplemental Data Report and Supplemental Information to the Final Environmental Impact Statement, Tocks Island Lake Project, N.Y., N.J., Pa., U.S. Army Engineer District, Philadelphia, Pennsylvania, 1974 (Draft-copy); Hammer, Siler, George Associates.

An interesting set of additional tests might have involved running tests number 11 and 12 as shown, except holding recreation benefits at $1.35 per visitor day. No narrative test was provided in the Corps' report in support of the sensitivity testing.

VIII.C.2(b) Overall Constraints and Impacts

There are several overall constraints on project formulation which have a significant impact on total project evaluation and on the evaluation of specific project purposes. Senate Document No. 97 places three specific constraints (period of analysis, discount rate and price levels) on project formulation and there are two less specific constraints (secondary and environmental benefits and costs) which impact on overall project feasibility. These overall constraints and impacts are described in some detail in the material which follows.

Period of Analysis --

According to Senate Document No. 97 "The economic evaluation of a project shall encompass the period of time over which the project will serve a useful purpose. Thus, the period of analysis should be the shorter of either the physical life or the economic life of the structure, facility, or improvement. However, because of the difficulty in defining the more remote future conditions and the discount of long deferred values, 100 years will normally be considered the upper limit of the period of analysis". (No specific direction is provided for considering periods of less than 100 years.) The original project formulation included in House Document 522

called for the period of analysis to be set at 50 years. Subsequently, the Philadelphia district office of the Corps of Engineers was directed by "higher authority" to set the period of analysis at 100 years. This direction was made pursuant to EP1165-2-1 (Digest of Water Resources Policies and Activities) which stated in part that "Even though a project might be needed indefinitely or for a very long period, the estimated useful economic life for the purpose of economic analysis is limited to 50 years, except for large reservoirs, major long-term urban flood protection and main line levees which have a 100 year project life". The 100 year period of analysis assumes that there will be no salvage value after 100 years and that there will be no benefits after 100 years. While the average annual benefits and costs are computed over a 100-year period, the actual economic projections are only carried 50 years and then "straightlined" for the balance of the period. The apparently arbitrary (but legal) establishment of a 100-year economic life for the project has been designed for multiple purposes each of which is subject to technological and economic impacts over a much shorter period of time. The 100-year period of analysis clearly optimizes the potential for developing a positive benefit to cost ratio.

Discount Rate --

Senate Document 97 specifies that "The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs, or otherwise converting benefits and costs to a common time basis shall be based upon the average rate of interest payable by the Treasury on interest bearing marketable securities of the United States outstanding

at the time of the fiscal year preceding such computation which, upon original issue had terms of maturity of 15 years or more". In addition, this document provides that "This procedure shall be subject to adjustment when and if this is found desirable as a result of continuing analysis of all factors pertinent to selection of a discount rate for these purposes". The discount rate used for the Tocks Island Lake project was set at 3-1/8 percent and frozen for purposes of benefit-cost analyses undertaken in succeeding years. All updates and revisions are prepared "as of" the time of approval by Congress (1961) and all figures are carried "as of". Opponents of the project have criticized the Corps of Engineers for utilizing this low discount rate in the face of spiraling interest rates over the past several years. The Corps' position is that its hands are tied since the requirement (constraint) was set by Congress. Any change in the interest rate would have to be at the direction of the Congress.

It is important to understand the sensitivity of the discount rate on the values of benefits and costs of projects like Tocks Island. Generally, the larger benefits get more heavily discounted, whereas the larger costs, being closer in time, are less heavily discounted. Thus, an increase in the discount rate nearly always reduces the present value of net benefits -- economic desirability. Very often the later years of project life make little difference in the economic evaluation of a project because these years are so heavily discounted. However, benefits from water quality and water based recreation areas may lie quite far in the future because of future population pressures, as may be the case with Tocks Island.

The impact of the relatively low 3-1/8 percent discount rate can be seen when compared with the new discount rate of 5-7/8 percent set by the Water Resources Council in its principles and standards. However, the Water Resources Council discount rate applies only to projects authorized and funded after 1969. Such projects have a floating interest rate which is reconsidered on an annual basis. Continued use of the low discount rate provided under Senate Document 97 is clearly a constraint on evaluation objectivity when average long-term interest rates are substantially higher.

Price Levels --

Senate Document 97 requires that "The prices used for project evaluation should reflect the exchange values expected to prevail at the time costs are incurred and benefits accrued. Estimates of initial project costs should be based on price relationships prevailing at the time of the analysis (in constant dollars). Estimates of benefits and deferred costs should be made on the hasis of projected normal price relationships expected with a stabilized general price level and under relatively full employment conditions of the economy." The experience with the national economy over the past 15 years since the project was proposed clearly indicates the need for an accounting of increases in cost and price levels for at least the period of construction. Past and current evaluation utilizing design year price levels places a real constraint on the reliability of the estimated real cost of the project for purposes of benefit-cost analysis.

Secondary Benefits and Costs --

Senate Document 97 has relatively little to say about the evaluation of secondary benefits. "Secondary benefits attributable to the project from a regional, state or local viewpoint...shall also be evaluated, when this procedure is <u>considered pertinent</u>, and an additional benefit-cost ratio computed." The Corps' rationale for not including secondary benefit analysis in the Tocks Island Lake project evaluation is twofold: 1) it is not required; and 2) it is too complicated. While not specifically directed to evaluate secondary benefits and costs by the Congress, the Corps could have eliminated considerable criticism of their methodology by undertaking analysis of at least selected critical secondary costs and benefits affecting local and state governments, i.e., highways and local governmental public services. While the evaluation of secondary impacts is not required in Senate Document 97, the fact that major criticism is directed toward this omission places a major political constraint on overall project feasibility.

Environmental Costs and Benefits --

Since the Tocks Island project was authorized a number of years in advance of the National Environmental Policy Act (NEPA) and the more recent Water Resources Council standards, there was no provision made for detailed analysis of environmental impacts or the benefits and costs related to the environment. Because of the current interest in matters affecting the environment -- such as the Tocks Island Lake project -- this must be looked upon as a constraint on project formulation. If the project were being formulated under the Water Resources Council principles and standards it

would now have to fully integrate into its analysis methodology a careful consideration of the benefits and costs attributable to the environment. It should be pointed out that the Corps of Engineers has in recent years undertaken studies of certain environmental issues (eutrophication, for example) and found that they will have minimal impact on water supply recreation.

The whole question of the benefit-cost analysis of environmental impacts is very much up-in-the-air in terms of the current state-of-the-art. Most environmental benefits and costs are by their very nature intangible and not readily subject to quantification. However, many analysts are now turning to qualitative analysis in order to project such impacts in terms that can be evaluated along with tangible benefit-cost data in making important decisions on projects having direct environmental impacts.

From our analysis, it is clear that the Corps of Engineers has attempted to follow the policies and standards articulated in Senate Document 97 and Supplement No. 1. This discussion of constraints and impacts and that which follows should not be construed as a criticism of the policy of the Corps of Engineers but rather as a statement of fact relating to the rules under which the Tocks Island Lake project was formulated. Modification of these policies and standards could have been made by the Congress, but they were not.

VIII.C.2(c) Constraints and Impacts on Project Purposes

Constraints and impacts affecting the four specific authorized project purposes relate to the overall constraints previously described and to constraints imposed by other governmental agencies. Specific constraints impacting on the authorized purposes of water supply, recreation, flood control and power are described in the paragraphs which follow.

Water Supply --

Assuming the justifiable demand, water supply can never be economically unjustified. Benefits will always be more than costs. In a water supply project, benefits accrued are equal to the cost of providing the same amount of water by the cost of the least costly alternative method. In the case of Tocks Island, the alternative was a smaller single-purpose dam. In evaluating this alternative, the federal interest rate of 3-1/8 percent is not used in computing costs since it is assumed that the water is to be provided by a non-federal entity, i.e., the Delaware River Basin Commission (DRBC). In this case, the cost of the project is discounted at a non-federal interest rate of 4-1/2 percent. This concept has not been accepted by many of the Corps critics, particularly in the case of the Tocks Island project. However, the Corps of Engineers must work within these constraints, since they are set by Congress. This differential discount rate is a bias established by Congress many years ago in order to assure approval of water supply projects. This constraint is carried forward under the new Water Resources Council principles and standards where the respective federal and non-federal interest rates are now 5-7/8 percent and 7 percent respectively.

Recreation --

The basic constraint affecting the recreation evaluation deals with the four million visitor days set as the maximum capacity for the recreation area by the DRBC at the request of the State of New Jersey. This figure is in direct conflict with the Corps of Engineers' projected 9.6 million visitor days that were developed in part from the Nathan report, state projections and a detailed in-house analysis undertaken by the Corps.

Beyond the maximum design capacity established by DRBC, a major constraint is set forth from Supplement No. 1 to Senate Document 97 which requires that a recreation day be computed for costing purposes at between $.50 and $1.50. For the Tocks Island Lake project, the Corps has estimated the cost per user day at $1.35. This is the figure used originally and the one that is currently used. Using standards developed by the Water Resources Council, the Corps has undertaken sensitivity analysis utilizing a 5-7/8 percent interest rate and a $2.03 cost per visitor day. The $2.03 figure was based on the original $1.35 and the WRC policy which authorizes up to a 50 percent increase in costs over and above those used under Supplement No. 1 The higher costs (benefits) and the higher discount rates tend to "balance out" so that the benefit-cost ratio remains essentially the same.

Operating under the imposed constraint of developing a design capacity for recreation facilities to serve just under four million visitor days, the Corps has developed a plan for facilities in two phases. The first phase is designed to meet the needs of 3,982,000 visitor days operating at full

capacity on opening day. The second phase allows the Corps to expand the capacity of the recreation facilities over a 10-year period in order to accommodate the projected 9,386,000 visitor days originally established for the recreation facilities. Beyond the original DRBC authorization to serve four million visitor days annually, the Corps has proposed continued development of recreation facilities based on annual funding to be authorized by the Congress. In effect, the Corps has ignored the constraint on capacity set by the DRBC so that over a period of time the project could be built to original planned capacity and so that the larger estimate of visitor days could be used in the benefit-cost analysis.

Flood Control --

Constraints affecting analysis of flood control benefits and costs are established in three types of flood damages that are considered by the Corps in their benefit-cost analysis. These include:

1. Existing damages to existing buildings, lands and facilities.
2. Future development as planned and zoned based on OBERS projections for population for only a 50-year period. No consideration (a constraint) can be given to potential future land use or flood plain zoning that could limit the amount of development in the flood plain area. Where existing flood plain zoning does exist, the Corps eliminates future development damages from its calculations.
3. Affluence is the income that residents in the defined flood area put into their homes over a period of time as improvements. The rate of affluence is computed at 65 percent of the change in per

capita personal income within the area affected. An additional constraint has recently been imposed by OMB which is now requiring benefit-cost calculations computed with and without the affluence factor. This results in two benefit-cost ratios.

Power --

The Corps of Engineers' benefit-cost analysis of the power purpose in a multiple-purpose project is constrained in that the Federal Power Commission in New York City is responsible for all data on power and related requirements used in the benefit-cost analysis. The FPC provides data on dependable capacity, interruptable capacity, and energy value. The Corps accepts these figures and applies the discount rate for the period of analysis (additional constraints) in order to attain a benefit-cost ratio.

VIII.C.2(d) Conclusions

The overall and specific project purposes constraints and impacts described above all have an impact on the output of the benefit-cost analysis. While there is certainly justification for criticizing the period of analysis, the discount rate, price levels and the lack of consideration for secondary and environmental benefits and costs, it must be stated that the Corps has followed the principles and standards adopted under Senate Document 97 and Supplement No. 1 for purposes of benefit-cost analysis. While each of these areas of constraint might have been modified somewhat by the Corps of Engineers, the responsibility for authorizing and directing such change lies with the Congress. We believe that Senate Document 97 and Supplement

No. 1 has provided a reasonable basis for the original benefit-cost analysis of the Tocks Island Lake project. In view of the length of time between the original analysis and the current evaluation, there is certainly justification for modifying the benefit-cost methodology to more accurately reflect the current state-of-the-art and to meet the currently adopted policies and standards of the federal government.

VIII.C.3 ENVIRONMENTAL CONSTRAINTS AND IMPACTS

VIII.C.3(a) General

In the development of the Tocks Island Lake Project the effects of the dam on the surrounding environment were taken into account and in some instances such effects were determined by the Corps to be serious enough to warrant changes in the project, bringing it to its present state of refinement. The environmental considerations which caused changes in the project are denoted as constraints in that they properly restricted the design and effects of the constructed project to various acceptable or tolerable boundaries. Examples of such constraints are the preservation of historical sites, construction of fish ladders, control of non-point discharges, and other such items. Environmental issues which cannot be resolved through redesign or which are of a lesser magnitude are called environmental impacts. In this particular project, some of the environmental impacts are the effects of the relocation of highways in the project area, the loss of over 10,000 acres of wildlife habitat, erosion during construction, and eutrophication due to the change from a river system to a lake system. Arguments over the environmental aspects of the project were bound to arise on an undertaking of such magnitude. These arguments revolve around not only the extent of modification to the project to mitigate the major environmental problems, but the advisability of the project itself. At the present time, the Corps of Engineers expresses the conviction that the benefits of the project more than outweigh the

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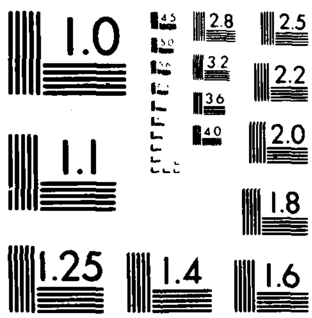

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the admitted environmental problems. Those opposed to the project say that the remaining environmental problems are not negligible and furthermore, that those harmful environment consequences for which the dam was modified to prevent from happening are not completely satisfied.

VIII.C.3(b) Review of Environmental Planning Constraints

In the design of the Tocks Island Lake Project the Corps of Engineers has been guided concerning environmental problems which arose in project formulation by the following constraints:

1) Avoid the construction of any structure (or action) causing serious adverse impacts upon the biota (direct or indirect).

2) Require the construction of any structure (or action) necessary for the subsistence of entrapped and migratory organisms (direct or indirect).

In addition, through the conducting of numerous environmental investigations the Army Corps of Engineers sought the advice and response of environmental groups within the three states (New Jersey, Pennsylvania, and New York) adjacent to the proposed reservoir site, and the State of Delaware. General Design Memoranda have been published (1968-1969), including a basic analysis of environmental considerations and group and agency responses. These have resulted in further planning constraints. Other documents of an environmental nature (public record) have been produced under direction furnished by the Council on Environmental Quality and include:

1) Tocks Island Lake Environmental Impact Statement, U.S. Army Corps of Engineers, 1 October 1971.

2) An appraisal of the Potential for Cultural Eutrophication of Tocks Island Lake, Jack McCormick and Associates, Devon, Pennsylvania, 22 September 1971, under contract to the U.S. Army Corps of Engineers.

3) Tocks Island Lake Development: A comprehensive Evaluation of Environmental Quality, U.S. Army Corps of Engineers, 1 October 1971.

4) Statement of Facts, U.S. Army Corps of Engineers, 1 October 1971.

5) Additional Data in Support of Statement of Facts, U.S. Army Corps of Engineers, 1 October 1971.

6) Supplemental Data Report and Supplemental Information to the Final Environmental Impact Statement Tocks Island Lake Project, U.S. Army Corps of Engineers, 1974.

Detailed analyses of environmental impacts are presented in various sections of this report. A brief review of the most significant impacts is presented here to focus on the mitigating measures possible regarding project formulation.

In terms of historical preservation, buildings having historical value will be relocated or preserved in accordance with a 1972 Court injunction. Surveys were made of the area to be inundated by the reservoir by the National Park Service. Photographs, measurements, and drawings were made of structures deemed to be of historical of architectural value to assist in their removal and relocation. The possibility of pollution problems caused by the project was known to exist and efforts to reduce their more serious effects were taken. The water quality in the Reservoir will be monitored for such water quality data as dissolved oxygen, salinity, pH and temperature. A

multi-level water quality monitoring station will be located in the intake structure and will be used in determining levels for selection of desired water quality. There will also be monitoring stations directly upstream of the reservoir at Port Jervis, New York. The U.S. Army Corps of Engineers proposed pollution control measures include the development of a sewage collection and treatment system. The Delaware River Basin Commission, was and is, responsible for developing the required sewage treatment plant; and, as such, provides for the handling of wastes from the communities projected to be established within the immediate watershed of the reservoir and the watersheds which are tributary to the reservoir as well as all wastes arising from visitors at the Tocks Island Reservoir and the Delaware Gap National Recreational Area. The plan includes the redirection of storm sewers which now discharge directly into the river upstream of Tocks Island into stormwater interceptors. The construction of culverts to handle hillside runoff where existing or proposed storm sewers do not directly enter the pumping stations or ponding area and the construction of gravity outlets or interceptor sewers draining to the pumping stations will be necessary. During periods when the flood levels are sufficiently high to make the gravity outlets inoperative, all water accumulations in excess of allowable pondage will be pumped.

Non-point sources of waste will be handled in accordance with establised EPA guidelines, including erosion and sediment control, efficient use of applied fertilizers and retention of animal wastes on the land.

These EPA guidelines currently require each state to develop needed non-point source regulatory program as knowledge, legal authority, and resources permit. The EPA encourages states and designated agencies to institute "Best Management Practices". The term refers to a practice that is determined by a state after examination of alternative practices to be practicable and most effective in preventing or reducing the amount of pollution generated by a non-point source to a level compatible with water quality goals. The potential problems with non-point sources as they are related to potential eutrophication will be covered in Chapter IX.

The need to preserve water quality during the construction of the dam is also pertinent and to achieve this goal the Tocks Island design provides environmental safeguards to prevent soil erosion and sedimentation. Control plans are being developed in accordance with requirements of Pennsylvania Department of Environmental Resources, and in particular the Pennsylvania Clean Stream Law.

In addition to water pollution, air pollution is another aspect the Tocks Island Lake Project which can be classified as a constraint. This problem will occur during the construction phase of the project and should be able to be controlled by contractual agreement with the contractor, such agreements covering dust control, open burning, as well as including pollution equipment and personnel of the contractor during construction. Additional air pollution problems may result from

the private automobiles which will in large part be the mode of transportation for the 4 million visitors expected each year. This problem will be covered in more detail in Chapters XVI and XXII.

Attempts have been made to mitigate the adverse affects of the dam and reservoir on the fish and wildlife of the area. The relocation of Highway 209 will make passage of wildlife across the area difficult and dangerous. In order to mitigate this adverse effect, it is planned to make the culverts under Highway 209 large enough to allow the passage of wildlife. The Pennsylvania Department of Transportation will install deer fence along the relocated highway while providing seventeen crossings for deer.

A large population of shad migrates up the Delaware River in spawning season with the resultant appearance of a huge number of fry. The adult fish are important for sport and food in the region. Construction of the Tocks Island Dam would interfere seriously with the shad migration unless a workable fish ladder is operable during the run. This is discussed in detail in IX.C.

To further mitigate effects on aquatic life below the dam, the discharges from the reservoir will be regulated to control river conditions downstream and satisfy the salinity requirements of the Delaware Bay estuary.

As part of the recreational aspects of the Tocks Island Project, the

reservoir will be stocked with game fish.

Beyond pollution control and fish and wildlife considerations, aesthetic and visual aspects of the project have also been considered and effort has gone into making the changed environment as pleasing as possible.

VIII.C.3(c) *Review of Environmental Planning Impacts*

In the previous section the efforts which the U.S. Army Corps of Engineers undertook in the formulation of the Tocks Island Lake Project to reduce environmental degradation were presented. In this section the environmental results of the project which the Corps has not attempted to ameliorate will be presented. These environmental consequences are considered impacts rather than constraints.

Such impacts will be broken into two categories: 1) those impacts which will occur during construction of the dam, and 2) those impacts which will be a result from the operation of the dam and reservoir. The impacts during construction will by their nature be short lived and end with the completion of the project. These are discussed in X.A. Those environmental impacts resulting from the operation of the dam will be long term, more serious, and are summarized below.

Approximately 10,215 acres of wildlife habitat will be destroyed by inundation, and approximately 5,850 acres may be adversely affected by flood control storage operations. The loss to wildlife production

will be principally through the inundation of bottom lands critical to the food sources for the deer herd. The development of project facilities will result in further losses of land and will alter movement of deer and other animals, thereby preventing full utilization of the habitat. An additional 4,500 acres of land will be required for directly related recreational activity. It is not expected that this area will provide a significant amount of hunting opportunity.

Eutrophication of portions of the lake that results from the Tocks Island Project is a potentially serious problem. The change from a river to a lake system will result in warmer water, reduced flow velocity and large areas of shallow water along the lake periphery. The soluble nutrients in the waters may be utilized by higher aquatic plants or algae, which may die, sink to the bottom and contribute to the organic buildup and subsequent biochemical oxygen demand (BOD). Section IX.A. addresses this in detail. In an attempt to reduce this problem the Council on Environmental Quality (CEQ) has recommended that the states in the Upper Delaware River Basin (New Jersey, New York, and Pennsylvania) provide top funding priority for advanced waste treatment to those communities within the basin. The CEQ also recommends that operation of an effective advanced waste treatment system and implementation of a non-point source pollution abatement plan be in effect prior to closure of the dam. The CEQ has attempted to obtain commitments and assurances from the Governors of the Delaware Basin States to resolve these problems. Such assurances, however,

have not been forthcoming.

Water quality problems may also result from runoff of water containing oil, dirt, and salts form roadway surfaces. Heavy salting of roads has been found to be very injurious to the environment and has been banned in several states. Another potential problem is the development of a low oxygen layer within the proposed reservoir, having adverse affects upon some of the desirable fish species (chain pickerel, walleye, pike and trout) that seek cool water layers in the summer.

Long-term and short-term water level fluctuations in the lake will occur due to natural lake inflows, the lake management program, and pumped storage generation. The changes in water level may adversely affect fish spawning and nesting, and plant rooting capability in the intermittent wet zone. The lowering of the lake will expose some areas which will require drainage to prevent secondary ponding to eliminate breeding grounds of mosquitoes and other nuisance sectors. (The Corps of Engineers should include such costs as part of the project total.) Low water will also expose unvegetated slopes causing a visual impact.

VIII.C.4 SOCIAL CONSTRAINTS AND IMPACTS

Project formulation considered both temporary and permanent impacts to the area. The need to relocate basin residents (about 2600) outside of the proposed reservoir area and the costs thereof affected site selection. Relocation of highway, telephone and power lines will create temporary problems and inconvenience for local residents. Local protection works in the Port Jervis - Matamoras area will impair the natural aesthetics for residents in these areas. Loss of stream fishing downstream from the dam and in reservoir areas was weighed as well as the addition of lake fishing in the area. Tax revenues and employment opportunities will eventually increase as well as the opportunity to develop downstream areas for improved and higher use due to elimination of flood hazards. The influx of people from urban areas generally associated with available lake areas and recreational opportunities will tend to change the rural nature of the area as it presently exists. Inherent with the population influx are pollution (air and water) problems and other related factors that impact on society, land use patterns, and development trends. Both beneficial and adverse affects were weighed and given consideration in the plan formulation process. The Delaware River Basin Commission Resolution Number 73-6 limits recreational development to a maximum of four million visits per year thereby limiting the recreation impact on highways and on water pollution in the reservoir.
Sections X.D. and XXIV.B. detail the foregoing and a range of other social impacts.

VIII.C.5 INSTITUTIONAL CONSTRAINTS

The principal institutional constraints associated with project formulation are those surrounding the following major decision points:

1. Modification of the interstate compact creating the Delaware River Basin Commission and opening of the 1954 Supreme Court decree entitled New Jersey v. New York, 347 U.S. 995 (1954). Primary upper watershed control is exercised by New York City's operation of their three reservoirs under the Supreme Court Decree. Under this decree minimum flow into the reservoir is expected to be no less than 1750 c.f.s., at the Montague Gaging Station, equivalent to 1800 c.f.s. at the dam. The most influential factor in future operation will be adherence to the Supreme Court Decree, or some modified agreement, acceptable to all parties, on releases from these three reservoirs. See Chapter XVII for a full discussion of the Decree.

2. Land use policies and development controls.

3. Cost sharing by the Federal Government of highways built or maintained by state, municipal and county governments in the impact area and adjacent to it.

4. Loss of tax ratables resulting from acquisition by the Federal Government of real property.

5. The impact on municipal and county governments in terms of their ability to finance services and additional facilities required for residents and visitors to the area.

In addition, there are institutional constraints that are not adequately addressed in project formulation relating to non-structural measures as viable alternatives to the proposed plan. Primarily these relate to state-enabling legislation or lack of such legislation in adjacent states creating conflicts in flood plain zoning, purchasing the flood plain, permanent or temporary evacuation, coordination of flood warning systems and structural design criteria for local protection projects. Other problems could arise in Water rights (compact agreements), disposal of diverted water and physical location of return flow. Implications of modifications to the interstate compact and Supreme Court decree are discussed in Chapter XVII.

VIII.C.5(a) Financing Highways

Several spin-offs of the Tocks Island project formulation could result in increasing needs for highways. Because of the location of the project impact area, its past dependence on highways and the density of development which will locate in the area, it was anticipated under project formulation that the greatest number of people will use privately owned automobiles to get to and from the area. This had several implications for the levels of highway service required. As Tocks Island enhanced economic development the population would increase. Forecasts showed substantial population increases of both temporary and seasonal residents could occur. The influx of tourists would have an important impact on the need for higher levels of highway service. These kinds of issues will be discussed in detail in Chapter XXV.D.

In order to provide the appropriate levels of service it would be necessary to improve existing highways and build new ones. The Federal Highway

Administration plays a pivotal role in funding highway improvements. Its programs are authorized by the U.S. Congress and funded through gasoline taxes for the most part. The Federal Highway Administration (FHWA) currently has programs for the construction of interstate defense highways, urban highway systems, rural highways, Indian reservation roads, and certain roads within and approaching national park areas and selected special highways specifically identified through legislation. Under the Federal-Aid Highway Amendments of 1974, access highways to recreation areas on lakes are eligible for 70 percent federal funding. However, the funding of local access roads is generally reserved for the state and local governments in which the roads are located.

State transportation departments have the principal responsibility for planning, programming and construction of highways within their borders. This includes commitments of federal funds and matching them with state highway revenues. Thus, both the federally assisted and state assisted highway systems are largely the responsibility of the states. Local access roads remain the responsibility of local governments with some state assistance.

A number of institutional issues result from the methods and procedures for the planning, programming and budgeting of highways. Unless a new federal highway program is authorized by the U.S. Congress federal funding of local roads required as a result of the Tocks Island project may not be forthcoming. A revision to the highway statutes coupled with FHWA's program administrative regulations would be required to provide a new source of federal funding to assist local governments in raising the levels

service of local roads within their borders. An alternative apporach would be greater state funding of highways. In recent times the revenue base for highway funding, state gasoline taxes, has been declining, or increasing at a slower rate, than heretofore anticipated. If gasoline consumption declines, less gasoline taxes will be available for highway construction from state governments. If gasoline consumption stabilizes and construction costs increase, fewer highways can be built with the same amount of money. Another approach to increasing funds available for local highway construction would be alteration of eligible Tocks Island project costs. The highway improvements serving visitors to the Tocks Island impact area will necessarily have to be made within jurisdictions outside the project boundary. This factor will have to be considered in any eligible project cost solution to the sharing of highway financing responsibilities.

These are the types of institutional issues necessary to evaluate in the formulation of the Tocks Island project. Amelioration of the highway financing issues could require federal legislation, and state legislation to increase their participation or alterations in the definition of eligible project costs. These approaches have ramifications for the cost-benefit equation discussed elsewhere in this Chapter.

VIII.C.5(b) *Loss of Tax Ratables*

The process of project formulation resulted in a project requiring federal acquisition of land prior to implementation. As the Federal Government acquires land for the project it is removed from the real estate property tax rolls of municipal and county governments. In some cases this can

result in depletion of the municipal and county government tax bases. Several years may be required to recapture the real property tax base as TILP and DWGNRA help attract development. Table 8-4 on the following page shows the dependence of municipal and county governments on real property tax yields within the seven-county impact area. From 21 percent to 75 percent of local revenues are a direct result of taxes on real property. Substantial reduction of these real property tax bases could impair the ability of local governments to provide the full range of services required to their residents. This is an especially important problem in cases where substantial portions of municipalities are acquired for federal purposes. County governments are less severely impacted by federal land acquisition because acquired properties represent a smaller proportion of their tax base than is the case with some municipalities.

Amelioration of this problem could require federal or state action to the extent that it is politically and economically feasible. Federal payments to municipal and county governments in lieu of taxes for those properties purchased by the Federal Government is one approach. State grants to municipal and county governments could help ease the financial strain placed on them by loss of tax ratables. This approach was used in Pahaquarry Township, Warren County, New Jersey. Partly due to federal land acquisition the population of the township has been reduced to 70 persons and its annual revenue to $27,068. The state makes payments to the township in order that it may continue to provide services to its remaining residents according to the Division of Water Resources, Department of Environmental Protection, State of New Jersey.

Table 8-4 Impact Area Local Government Dependence on the Real Property Tax

Impact Area Local Government	Total Tax Revenues	Real Property Tax Revenues	Percent Property Tax Revenues
New Jersey 1/			
Sussex County	$13,352,809	$ 8,654,733	64.7%
Municipalities in Sussex County	$47,333,910	$35,617,133	75.3%
Warren County	$ 9,461,356	$ 5,458,435	57.7%
Municipalities in Warren County	$33,139,917	$22,161,849	66.9%
New York 2/			
Orange County	$53,193,256	$21,563,914	40.5%
Local Governments in Orange County	$113,745,748	$46,589,103	41.0%
Sullivan County	$23,102,146	$ 4,930,630	21.3%
Local Governments in Sullivan County	$30,536,888	$17,017,324	55.7%
Pennsylvania 1/			
Monroe County	$ 3,329,048	$ 1,466,462	44.1%
Local Governments in Monroe County	$ 4,958,482	$ 1,024,601	20.7%
Northampton County 3/	$15,686,924	$ 6,534,312	41.7%
Local Governments in Northampton County	$21,116,686	$ 6,770,713	32.1%
Pike County	$ 757,595	$ 290,296	38.3%
Local Governments in Pike County	$ 1,416,168	$ 525,535	37.1%

Notes:
1/ Data for year ended December 31, 1973.
2/ Data for year ended December 31, 1972.
3/ Data for year ended December 31, 1970.

Sources: Division of Local Government Services, Department of Community Affairs, State of New Jersey; Comptroller of the State of New York and Bureau of Local Government Services, Department of Community Affairs, Commonwealth of Pennsylvania.

VIII.C.5(c) Provision of Public Services

In spite of federal land acquisition requirements most municipal and all county governments will continue to have responsibilities for the provision of public services to their residents. One problem brought on by federal acquisition of properties has been the need to continue serving private property owners regardless of their location within the jurisdiction. To the extent that these property owners are interspersed among federally acquired property over time, it may be more costly to the municipal and county governments to provide services to them. In general, denser development is less expensive to serve than dispersed development. Unless the demand for services declines as rapidly as the real property tax base municipal and county governments may not be sufficient to provide services to those residents continuing to live within the jurisdiction.

As economic development of the seven-county impact area continues the population will rise and result in the need for additional public services. Both permanent and seasonal residents contribute to this need for services. Tourists in the area place special demands on selected public services such as police protection, highways, utilities and municipal parks. Unless the real property tax base,upon which municipal and county governments depend, expands with the demands for services by each of these groups, a gap may result between the cost of services and revenues available to support them.

At the same time there could be a net increase in property values. Private development constructed as a result of the Tocks Island project, such as those to serve tourists, permanent and temporary residents, and the residential areas for both, could result in increasing tax bases in selected municipalities and counties. Obviously, to the extent that these tax bases increase fast enough to pay for services required of visitors and residents alike, the public service issue is ameliorated.

VIII.D. SERVICE AREA NEEDS MET BY THE T.I.L. PROJECT

The Tocks Island Project as currently planned and described in General Design Memorandum No. 3 was analyzed as to the extent to which the project could meet current estimates of present (1980) and future (2010) needs of the Delaware Service Area. Results of this analysis shows that Tocks Island Project satisfies about 60 percent of the present needs for two of the authorized purposes of flood control and water supply and 8 percent of the needs for recreation. A summary of the needs and proposed goods and services produced by Tocks Island Project are given in Table 8-5 . As noted previously, these estimates are based upon mandated assumptions and procedures imposed by Congressional action on the Corps' analyses.

Table 8-5 Service Area Needs Met By Tocks Island Lake Project

Purposes	Measure of Needs	YEAR - 1980 Area Needs	YEAR - 1980 Needs Met by the Tocks Island Proj.	YEAR - 1980 Percentage of Needs Met	YEAR - 2010 Area Needs	YEAR - 2010 Needs Met by the Tocks Island Proj.	YEAR - 2010 Percentage of Needs Met
Flood Control	Dollar Benefit	$2,090,700 (1)	$1,249,000 (1)	60% (1)			60% (1)
Water Supply	MGD	3,080 (2)	1,803	59%	6,119 (2)	1,803	29%
Recreation	Visitors Annually	48,181,000 (3)	4,000,000	8%	138,500,000 (3)	9,500,000	7%
Conventional Power	KWH		307,000,000			307,000,000	
Water Quality	MGD				1,393	-0- (4)	0%

(1) Based on 1965 Price Level at 1965 Level of Development (Percentage would remain approx. the same through year 2010).

(2) Gross water needs of the Trenton-Philadelphia Area to be secured from Surface waters.

(3) Based on potential recreation demands prepared by Corps of Engineers and Bureau of Outdoor Recreation for a radius of 300 miles from Tocks Island Project. (See DM #3-Page III-13)

(4) Although no specific provisions are planned for water quality in Tocks Island Project, incidental benefits from dilution downstream will result from releases of stored water for other purposes.

Source: General Design Memorandum No. 3., Corps. of Engineers.

IX.A. EUTROPHICATION

IX.A.1 INTRODUCTION

This chapter discusses fundamentals of limnology and studies conducted under contract to the U.S. Army Corps of Engineers and the Delaware River Basin Commission to assess the potential for cultural eutrophication at the proposed Tocks Island Lake. It includes a brief discussion of a few other publications pertinent and useful both in describing conditions in the proposed lake that may have a bearing upon its trophic state and in predicting the trophic state once the lake is created. A general introductory discussion of limnology is included in Appendices IX.A.1 and IX.A.2 to aid the reader of this and following water quality chapters. For more specific information the reader is referred to one of the current excellent text books on limnology (Ruttner, 1971).

It is important that the reader and the decision-maker appreciate the complexity of this subject and appreciate the reasons why experts are unwilling to commit themselves to a dogmatic position.

The purposes of this chapter are to discuss the nature of the trophic state of the lake, to review the attempts to predict the trophic state of the proposed Tocks Island Lake, to assess independently the trophic state, and to discuss the impact of eutrophication upon the beneficial uses of the lake.

The trophic condition of a lake refers to the supply of nutrients that support algae growth being supplied to the lake water each year and to the subsequent response of the algae in the lake to those nutrients. The term oligotrophic refers to an under-enriched condition; that is, the input of nutrients -- primarily nitrogen and phosphorus species -- is not sufficient, and the algal growth rates are too slow for a large standing biomass of algae to develop. Oligotrophic lakes are usually deep, cold, and clear. Most high mountain lakes are in this trophic state.

The term mesotrophic refers to a condition of moderate enrichment with nutrients, and a moderate response to those nutrients by algae in the lake to create an appreciable but not detrimental standing biomass of algae.

The term eutrophic refers to the condition of over-enrichment where the rate of nutrients supplied to the lake and the rate of algae growth create, at least at some time during the year, a high standing

biomass of algae. Eutrophic conditions are observed in many lakes in the eastern and western United States. Lake Washington in Seattle, until the early 1960s, was in a state of accelerated eutrophication. Some of the reservoirs in the upper Delaware River Basin, namely Cannonsville and Allegheny, are also experiencing accelerated eutrophication. Algae cell concentrations within Cannonsville Reservoir have been recorded as high as 30 million cells per liter, a concentration that is considered to be quite high and indicative of a highly eutrophic condition.

The term eutrophy or eutrophic has come to be a household scare word that sometimes brings to mind the appearance of soupy green water in a lake or river that once was cold and blue, of fish dying by the thousands, suffocating for lack of oxygen, and bathers pushing the large masses of floating green matter out of their way as they swim along. This picture is not universally true. In fact, it is the exception rather than the rule.

Many lakes classified as "eutrophic" by limnologists might receive only passing notice by an untrained observer. Eutrophy often enhances fish populations. There is no universally accepted classification scheme that says oligotrophic means "good" and eutrophic means "bad." In this subject, as with most subjects, value judgements vary widely between people.

The question that has been asked about the proposed Tocks Island Lake is whether it will be eutrophic, if so to what degree, and how will the condition affect the planned uses of the lake for water supply, power generation, flood control, and recreation. Since 1970 this question has engrossed many researchers. Hull (1975) reviewed critically and thoroughly the studies that have been performed to date, attempting to answer the question. This study also reviews and evaluates previous research, but to avoid bias in thought, all previous works were considered chronologically, taking Hull's review last.

The "Summary Evaluations" of this study regarding eutrophication are contained in Section IX.A.6. The impact of eutrophy on beneficial uses is discussed in IX.A.6.(e). Phosphorus control strategies are outlined in IX.A.5.(e).

The principals acting as reviewers of the information within (IX.A) were:

Dr. Wesley Bradford, previously a water quality engineer with URS, presently water quality consultant in private practice, Menlo Park, California.

Dr. Joseph Shapiro, Limnological Research Center, University of Minnesota.

Dr. Raymond K. Linsley, P.E., Department of Civil Engineering, Stanford University, Palo Alto, California.

IX.A.2 HISTORY OF THE CONCERN OVER POTENTIAL EUTROPHICATION IN TOCKS ISLAND LAKE

This section is intended to provide a review of the events and studies that have created the present situation of concern over the potential for eutrophication in the proposed Tocks Island Lake. It will attempt to put the impact of the various studies in perspective.

These studies, in chronological order, are as follows:

Tocks Island Regional Environmental Study, Volume II of Appendices by Roy F. Weston, Inc., Westchester, Pennsylvania, April, 1970.

An Appraisal of the Potential for Cultural Eutrophication from Tocks Island Lake, by Jack McCormick and Associates, Devon, Pennsylvania, September 1971.

Ecologic Simulation; Tocks Island Lake, Water Resources Engineers, February 1971.

Tocks Island Lake: Techniques for Water Quality Management by WAPORA, Inc., Washington, D.C., Feb. 1973.

Limiting Nutrient Study of the Delaware River at Montague in relation to the Proposed Construction of Tocks Island Reservoir by G.W. Fuhs and S.P. Allen, State of New York, Department of Health, December 1974.

Appendix C contains a further technical discussion and evaluation of the models contained herein.

IX.A.2(a) The Cahill Study

The first quantitative indication of potential cultural eutrophication in Tocks Island Lake was described by Thomas Cahill in 1968. At the

time, Cahill was working for Roy F. Weston, Inc., a contractor to the Delaware River Commission for the Tocks Island Regional Environmental Study (TIRES) that developed several alternative wastewater management plans for the Tocks Island Region.

Apparently Cahill's study was intended to be an exercise at obtaining data from the literature and programming a computer for a simple accounting scheme. Unfortunately, he decided to perform the study for the worst possible conditions, that is, using flow records for the period 1961-1965 in Delaware River. This was the period of the longest and most severe drought on record, estimated to have a recurrent interval of 100 to 500 years (Hull, 1975). Therefore, phosphate concentrations he predicted could occur once every 100 years, and possibly not more than once every 500 years.

From limited data on phosphate concentrations in the Delaware and Neversink Rivers, Cahill calculated the rate of phosphorus loading to the lake from these natural resources. Then, using the population projections and the projections for visitors in the Delaware Water Gap National Recreational Area over the period of 1970 to 2020,* he estimated the phosphate flow introduced into the area from domestic sewage. Combining the sources, background flow in the Delaware River and

* The visitor load projected at that time has since been reduced (see XVIII).

the projections for phosphate loading, he estimated the phorphorus loading rate to the impoundment in 5-year intervals to the year 2020. Over the same time interval, and using river flow data that were collected during the drought period, he calculated the daily inflow of water into the impoundment. The average phosphorus concentration in the impoundment was calculated each day by dividing the total phosphorus content by the volume of impounded water.

He ran the accounting over a period of 2,040 days and presented the results graphically. The accounting showed that at the end of the second year after closure of the dam, the phosphorus concentration would exceed at all times the critical concentration for algal growth stimulation suggested by Machenthun (1965) to be 0.015 mg/l.

While the results of the arithmetic accounting are interesting, the study does not lend itself for use as a basis for arriving at decisions on wastewater management concerning the Tocks Island Lake. This is because, in addition to using 1961-1965 data, Cahill made two assumptions, namely that the impoundment is totally mixed at all times, and that phosphorus is a conservative constituent. That is, that its concentration is affected only by dilution or evaporation and not by any other physical, biological or chemical process. A 37-mile long reservoir cannot be well mixed instantaneously. Furthermore, it is well known that phosphate is not a conservative substance. For example,

data from the Cannonsville Reservoir indicate a decrease in the total dissolved phosphorus concentration of nearly 50 percent from the time the water enters the reservoir until the time it leaves.

Viewed in a historical context, Cahill's arithmetic accounting study was useful because it warned of a potential problem, but it cannot be considered the final statement on the question of the trophic level in Tocks Island Lake. For further disucssion see Appendix IX.A.3.a.

IX.A.2(b) The McCormick Study

In 1971, largely in response to the concern caused by the Cahill study, the U.S. Army Corps of Engineers contracted Jack McCormick and Associates, Ecological Consultants, to investigate the potential for cultural eutrophication in the lake. The McCormick team conducted a thorough and scholarly review of the literature on the causes of eutrophication and attempted to find a simple and useful model that would assist in predicting the trophic state of the Tocks Island Lake.

Their conclusion was that no models then existed that would enable adequate evaluation of the eutrophication potential. The McCormick team decided to forego any attempt to recalculate nutrient loadings but instead decided to use Cahill's original data. They calculated the mean phosphate concentration entering the impoundment and compared this figure with the phosphorus concentration entering Cannonsville

and Pepacton Reservoirs. Concentrations were three times higher in water entering the Cannonsville than in water that would enter Tocks Island Lake. Cannonsville Reservoir is highly eutrophic with heavy algal blooms occurring during the summer. Despite the difference in phosphorus concentrations entering the three lakes, the McCormick group concluded that the Tocks Island Lake would probably look like the Cannonsville Reservoir. This conclusion was not well substantiated. For further discussion see Appendix IX.A.3h.

IX.A.2(c) The WRE Study

In 1972, the U.S. Army Corps of Engineers contracted Water Resources Engineers, Inc., to develop a mathematical model of the ecologic system in order to simulate this system in the proposed impoundment. The Water Resources Engineers (WRE) model is a highly sophisticated attempt to describe physical, chemical, and biological conditions in the lake by conceptually dividing it horizontally into several sections that could be individually treated as continuously stirred tank reactors wherein the chemical and biological processes would reach a steady state. Each section or tank reactor is connected with those adjacent to it, and can transfer materials to them. The model can be made to simulate natural conditions by decreasing the time interval required for the reactors to reach steady state. Of course, as the size of the sections and time intervals decrease, the amount of data handling increases. The WRE model predicted that highly eutrophic conditions

would not develop even if secondary treatment, rather than tertiary treatment with 95 percent phosphorus removal, were provided for domestic sewage within the TIRES area. Sensitivity analyses of the model indicated that tertiary treatment of these wastes would reduce the size of the late summer algal bloom substantially to an average cell concentration of 10,000 cells per liter less than the concentration generally considered a heavy bloom.

The WRE analysis, however, had three deficiencies. First, the implicit assumption of the model is that each segment of the lake, which consisted of a layer two meters thick running the entire length of the lake, was completely and instantaneously stirred. This is an unrealistic assumption and the need to incorporate it in the model erased a great deal of detail in the water quality conditions along the longitudinal axis of the lake.

Secondly, nowhere within the discussion of the model was there an indication that WRE took into account mechanisms for releasing phosphorus from the sediments whereas mechanisms for deposition of phosphorus were incorporated into the model. In fact, the differential equation describing the transport of phosphorus into the water layer adjacent to the bottom sediments had a zero coefficient where transport from this process should have been. No realistic model of a lake can overlook the interactions between sediment and water in the transfer of constituents, especially nutrients.

Thirdly, there is some indication (Fuhs and Allen, 1975) that WRE was overly optimistic on the rate of zooplankton grazing. The springtime bloom that the model predicted to occur in early April was rapidly removed by zooplankton grazing. Blooms also occur in Cannonsville, Allegheny and Papacton Reservoirs, and there is little indication that zooplankton grazing reduces the algal biomass significantly. However, no studies on zooplankton grazing in these reservoirs are known to be available. For further discussion see Appendix IX.A.3.c.

IX.A.2(d) The WAPORA Study

Recognizing the different opinions expressed by the McCormick group and Water Resources Engineers on the potential for cultural eutrophication of the impoundment, the U.S. Army Corps of Engineers next contracted WAPORA, Inc., to assume that in the absence of adequate controls, an excessive or harmful degree of eutrophication would occur, and to study the feasibility of various in-lake controls. In order to establish the degree of the problem, the WAPORA group attempted its own evaluation of the potential for eutrophication. They completely recomputed the phosphorus loading rate to the impoundment basing their calculation on the latest data from the U.S. Geological Survey and the Delaware River Basin Commission monitoring stations, and upon flow data that more reasonably approximated average conditions.

Brezonik (1972) had published the results of the study of 55 small lakes and ponds in Florida in which the nitrogen loading rate and the

mean depths of the lakes were related to the trophic states. Since Brezonik had determined the relationship for nitrogen, the WAPORA group apparently employed the approximate stoichiometric atomic ratio of phosphorus to nitrogen (1:15) in phytoplankton to convert Brezonik's nitrogen-based criteria to a phosphorus basis. The acceptable and critical phosphorus loading rates for Tocks Island Lake with a mean depth of approximately 15 meters were then determined and compared with the new loading rate calculated by the WAPORA group. The calculated loading rate was substantially higher than the loading rate designated by Brezonik as critical (after the transformation described above had been performed so that the criteria related to phosphorus loading). According to these criteria then, the lake would experience severe cultural eutrophication.

Conceptually, the best method for predicting trophic conditions in a proposed lake is to compare the parameters known to affect the trophic level with those same parameters in existing lakes in various trophic states. The parameters best compared according to Imboden (1974), are the phorphorus loading rate, the mean depth, and the flushing rate, or some measure thereof. However, the attempt to perform this type of comparison by WAPORA is open to question. First, using the properties of small lakes and ponds in Florida to predict conditions in a large lake in Pennsylvania is questionable. Secondly, the transformation used to relate the trophic state to the phosphorus loading rates rather

than the nitrogen loading rate as originally performed by Brezonik is questionable. The phorphorus:nitrogen ratio in phytoplankton is known to range between 1:35 and 1:5, with 1:15 being a generally accepted average. Thirdly, Brezonik did not take into account the flushing rate of his lakes. Fuhs and Allen (1974) have suggested that variations in the flushing rate of the Florida lakes may account for variance in Brezonik's data. For further discussion see Appendix IX.A.3.d.

IX.A.2(e) Fuhs and Allen Study

The study performed by Fuhs and Allen (contract to DRBC) was originally intended to identify the particular nutrients that would limit phytoplankton growth in Tocks Island Lake. Because of the concern over the eutrophication question, however, Fuhs and Allen provided information beyond the original scope of their work and developed one of the most convincing predictions of the trophic state of the lake developed to date.

Using bioassay techniques they determined that nitrogen and phosphorus were the nutrients in low enough concentration to limit phytoplankton growth. It was clear that whenever available nitrogen concentrations were too low to support green algae and diatons, the blue-green nitrogen-fixing algae would predominate and produce sufficient available nitrogen so that other species could then survive and grow. Thus, for all

practical purposes, phorphorus is the nutrient in limiting concentrations in the Delaware River and would be also in the proposed Tocks Island Lake.

The preliminary results of a study by Fuhs and Allen were reported in a draft paper submitted December 1974 and a final submitted in early 1975. Their conclusions indicate that the impoundment is expected to be highly eutrophic but not as seriously eutrophic as indicated by the WAPORA study. Fuhs and Allen's prediction is based upon the work of Vollenweider, first published in 1968 and revised for publication in 1974, and the work of Imboden (1974) which is an expansion of Vollenweider's earlier work. For further discussion see Appendix IX.A.3(e).

IX.A.2(f) Review by Hull

Hull (1975) provided a lengthy and thorough discussion of the methodology and techniques used in the first four of these studies and criticized the techniques used and the conclusions reached by each. Hull concluded that each study made mistakes that impair or invalidate the conclusions and each was forced to make unrealistic assumptions in order to complete the job. As a result, questions concerning the trophic state of the lake have not yet been answered to the satisfaction of an indifferent observer. Hull concluded that the effects of a eutrophic condition, if it occurs, upon the beneficial uses of water supply, power generation, and flood control would be negligible or non-existent. Hull was less certain about the potential impact upon recreation.

IX.A.3 AN UPDATED APPLICATION OF MODELS

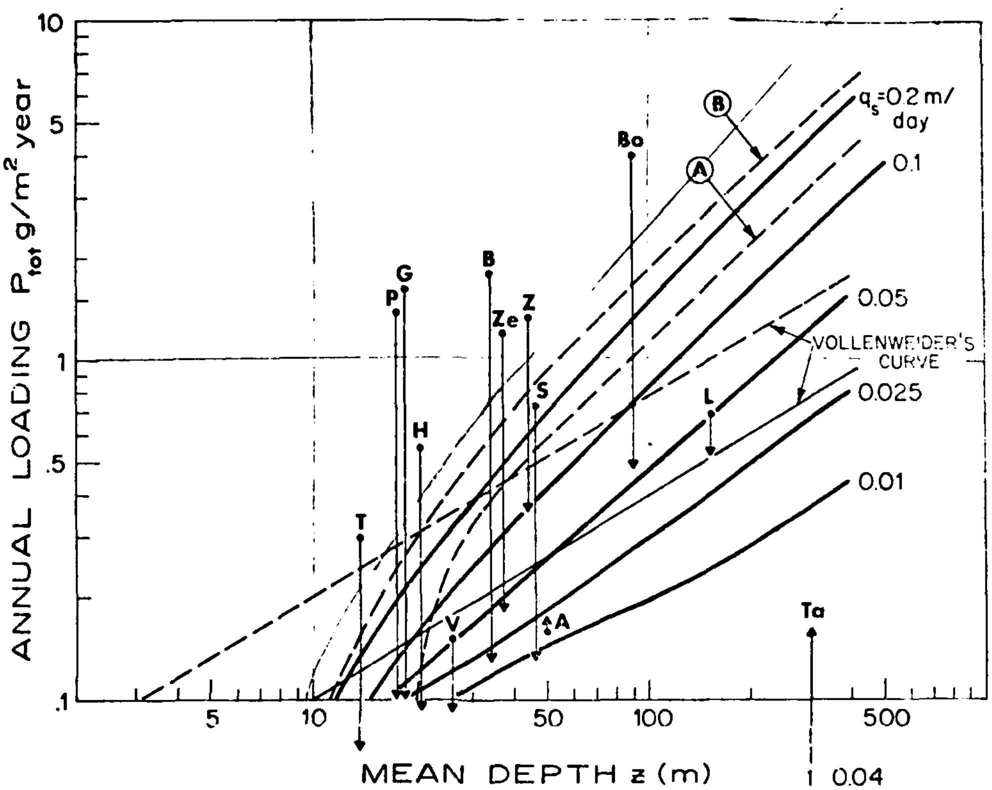
URS has continued the process of applying models to the prediction of the trophic state of Tocks Island Lake. The predicted hydrologic regime of the proposed Tocks Island Lake presented in IX.A.5(d) points to the fact that a majority of epilimnetic waters will have to be withdrawn from the reservoir over an extended number of months to satisfy the downstream temperature requirements (see Chapter IX.B). Tocks Island Lake, even though it is a reservoir with selective withdrawal capabilities, is expected to act for much of the year like a classical lake with a surface discharge. Models by Imboden (1974) and Dillon (1975) were developed to predict the trophic state of classical lakes. These two models were analyzed and applied to Tocks Island Lake. Imboden's model was also revised to allow for more severe evidence of eutrophication.

IX.A.3(a) Imboden's Model

Imboden (1974) discusses Vollenwieder's work and makes use of his data in his own study. Imboden set the goal of the study to "...describe the large class of lakes with a few common parameters in order to compare them in particular ways, and its (the model's) assumptions therefore represent a compromise between simplicity and reality." He began by taking a deterministic viewpoint, that is, that the processes within a lake may be approximated by a few first-order differential equations. The differential equations may be combined and solved to

give a real solution. In his approach he was able to take into account the hydraulic loading factor, the phosphorus factor, the mean depth of the lake, the rate of water exchange between the hypolimnion and the epilimnion, the velocity of sedimentation, the rate of photosynthesis, the mineralization rates (rate of regeneration of usable phosphorus) in both the hypolimnion and the epilimnion, and the exchange of phosphate at the sediment water interface.

After a number of simplifications were made that enable the solution of the differential equations, he was able to express the changes in dissolved oxygen concentrations in the hypolimnion over the summertime stagnation period (assumed to be approximately 180 days), that is, the time between the creation of the thermocline in springtime and the fall overturn, in terms of all the parameters mentioned. As a means of characterizing the trophic state of lakes, he set the total change in oxygen concentration, characteristic of the beginning of eutrophy, at one milligram per liter. He presented the results as a family of curves showing a range of hydraulic loading rates plotted on a field of annual phosphorous loading rates (in grams per square meter per year) against the mean depth in meters. Imboden's (1974) figure and table of lake data used in verifying the model are shown in Figure 9-1 and Table 9-1.



Tolerable annual phosphorus loading per lake area $L_{t,max}$ as a function of mean depth z for different hydraulic loading factors q_s. Comparison of theoretic $L_{t,max}$ for oligotrophy with the empirical curve by Vollenweider (1968). Choice of model parameters: $\alpha = 1$ day^{-1}; $g = 0.2$ m day^{-1}, $z_E = 10$ m; $R_H = 0.02$ day^{-1}; $R_E = 3$ R_H; $\xi = 0.001$ day^{-1}. In addition, two extreme cases with $q_s = 0.02$ m day^{-1} are plotted to demonstrate the sensitivity due to the variation of R and ξ. Curve A: $R_H = 0.02$ day^{-1}, $\xi = 0.01$ day^{-1}; Curve B: $R_H = 0.003$ day^{-1}, $\xi = 0.001$ day^{-1}. The points show the present condition of the lake, the end points of the arrow the theoretic $L_{t,max}$.

Table 9-1. Lakes Appearing on Figure 9-1

NAME	SYMBOL	MEAN DEPTH (meters)	HYDRAULIC LOADING FACTOR q_s (m/day)	PHOSPHORUS LOADING FACTOR L_t (g/m^2/year)	PERMISSIBLE L_t (Based on more liberal critera)	RATIO L ACTUAL to L_t PERMISSIBLE
Baldeggersee	B	34	.015	1.80	1.1	1.64
Lake Constance	B_o	90	.058	4.00	4.7	.85
Greifensee	G	19	.037	1.60	1.0	1.60
Pfaffihersee	P	18	.033	1.36	1.0	1.36
Zurichsee	Z	44	.098	1.32	3.6	.37
Zellersee	Ze	37	.038	1.20	1.8	.67
Tocks Island (by WAPORA)	T_1	13.1	.28	3.14	1.2	2.62
Tocks Island (Fuhs & Allen, 410 ft)	T_2	13.1	.28	6.07	1.2	4.89
Allegheny	A	14.5	.14	4.13	0.9	4.59
Cannonsville	C	19	.052	2.30	1.6	1.44
Wahnbach	W	19	.090	4.26	1.0	4.26

The real strength of the model appears in the verification. First, the agreement between this model and that developed by Vollenweider (unpublished) was very good. Secondly, he found that the trophic statesof fourteen lakes (thirteen in Europe and Lake Tahoe in the United States)were predicted correctly by the model. In all cases, the annual phosphorous loading rate for eutrophic to mesotrophic lakes was well above the predicted, tolerable limit. The two oligotrophic lakes, Lake Tahoe and Lake Aergerisee, are at annual phosphorous loading rates below the predicted tolerable limit. The annual phosphorous loading rate for the proposed Tocks Island Lake places the lake on Imboden's plot well above the tolerable limit and far above any of the other lakes considered. The hydraulic loading factor for the lake at maximum pool that would be required for the lake to avoid the onset of eutrophy may be as high as six meters per day, according to the model, whereas the lake is expected to have an average hydraulic loading factor of about 2.5 meters per day. Another way to state it is that the tolerable phosphorus loading rate is approximately .2 grams per square meter per year, whereas Fuhs and Allen (1974) calculated the phosphorus loading rate at approximately 5 grams per square meter per year.

The application of Imboden's work in predicting the trophic state of Tocks Island Lake is subject to several criticisms.

The Shape of Tocks Island Lake is Odd.

This model, like virtually all of the models used to predict the trophic state in this proposed impoundment, has not successfully simulated the special problems of a long, thin lake. The lakes used by Imboden (1974) and Vollenweider (as cited by Imboden) were much more regular in shape.

The Chosen Measure of Eutrophication is Rather Severe.

Imboden chose to use a dissolved oxygen decrease of one milligram per liter over a 180-day stagnation period as a measure for the early stages of eutrophication. It is safe to assume that in Tocks Island Lake a more severe drop in the dissolved oxygen concentration would be tolerated before remedial action to curb deterioration of the lake would be taken.

The Stagnation Period is Too Long.

The temperature model developed by Water Resources Engineers (1973) suggests that a substantial thermocline will not develop and be maintained for six months in the proposed impoundment. The model suggests that a stagnation period of sixty to ninety days might better approximate the situation in Tocks Island Lake. Thus, the tolerable annual phosphorus loading rate may be adjusted upward proportionately.

According to Imboden's equations, the relationship between the change in dissolved oxygen ΔO, the duration of stratification T_{st} and the phosphorous loading rate L_t may be represented as

$$\Delta O = C_x T_{st} \times L_t$$

where C is a constant containing several terms including the hydraulic loading factor. If we increased the tolerable reduction in dissolved oxygen by a factor of 3 to 3.0 mg/l and reduced the time of stagnation to 1/3 or 60 days, the permissible phosphorus loading rate would be increased 9-fold. In the case of Tocks Island Lake, the increase would be from 0.2 to 1.8 grams per square meter per year. This is still lower than the loading rate projected for the lake by Fuhs and Allen (5.87) by a factor of 3.3 and the loading rate projected by WAPORA (3.14) by a factor of 1.7. Thus some reasonable adjustments in the model give essentially the same prediction -- eutrophication will occur to a significant degree.

The Model Verification is not Completely Satisfactory

Inspection of Table 9-1 reveals that the lakes used by Imboden (1974) and by Vollenweider (1968) to verify their models all had fairly long flushing times relative to depth, that is the hydraulic loading factors (qs), the ratio of the mean depth (Z) in meters to the retention time in days, was rather small. The largest qs was

0.098 meters/day (36 meters/year)-the value for the Zurichsee. Fuhs and Allen extended the verification by adding the Allegheny (q_s = .14) the Cannonsville (q_s = .090) and the Wahnbach (q_s = .052) lakes to the analysis. The positions that these lakes take on Imboden's plot are shown in Figure 9-1. None of these lakes approaches the hydraulic loading factors expected for Tocks Island Lake of 0.28 meters/day at normal pool height.

It would be useful to verify the model using reservoirs and lakes in the three-state area that have flushing rates and hydraulic loading rates closer to that projected for Tocks Island Lake.

Verification should be extended to the northeastern Pennsylvania lakes for yet another reason. There is no guarantee that the chemical properties of soils -- especially the phosphorus exchange properties -- are the same for northern European and northeastern Pennsylvania soils. As the sediments of the lake will derive partly from eroded soils, the particular exchange characteristics of those sediments may have an impact upon the trophic state of the lake. The application of Imboden's model for predicting the trophic state of Tocks Island Lake presumes a similarity between the chemical characteristics of both soil types. We do not expect a great difference and so are not inclined to discount the model's application on these grounds.

IX.A.3.b Revision of Imboden's Criteria

Imboden (1974) utilized criteria for the beginning of eutrophy in a lake that may be considered quite conservative. In order to use the model to indicate the beginning of eutrophy with more liberal criteria, we have attempted to revise the equations to determine (1) whether a severe violation of assumptions would occur if more liberal criteria were applied and (2) whether the equations would be altered by new criteria. It was concluded that neither problem would arise through this revision.

Essentially, more liberal criteria may be applied directly to Imboden's equation 12 which is simplified to read as follows:

$$\Delta\ [O_2] = C \times L_t \times T_{st}$$

where T_{st} is the duration of stagnation in days, $\Delta\ [O_2]$ is the change in dissolved oxygen concentration and L_t is the loading rate of total phosphorous in grams per square meter per year. The constant (C) contains numerical constants and the functions q_s and z, the hydraulic loading factor and mean depth respectively.

For the purposes of demonstration, it is only necessary to change the conditions of T_{st} and $\Delta\ [O_2]$ in proportion to the conditions for which Imboden drew his original figures and redraw the scale of L_t. The values of q_s and z are independent of T_{st} and L_t.

For the simplicity, we chose to decrease T_{st} and increase Δ [O_2] in proportion to the original criteria (T_{st} = 180 days and Δ [O_2] = 1 mg/l) so that any combination of the increase and decrease factors multiplied together equaled 10.

The WRE report, in Figure V-2, indicated that their model predicted a duration of stratification of about 90 days, or one-half as long as the T_{st} used by Imboden. Thus, we use a Δ [O_2] in the hypolimnion criteria of 5 mg/l, five-times as large as Imboden's criterion. This criterion may be considered as liberal as possible. A larger Δ [O_2] would porbably place a severe hardship on benthic animals.

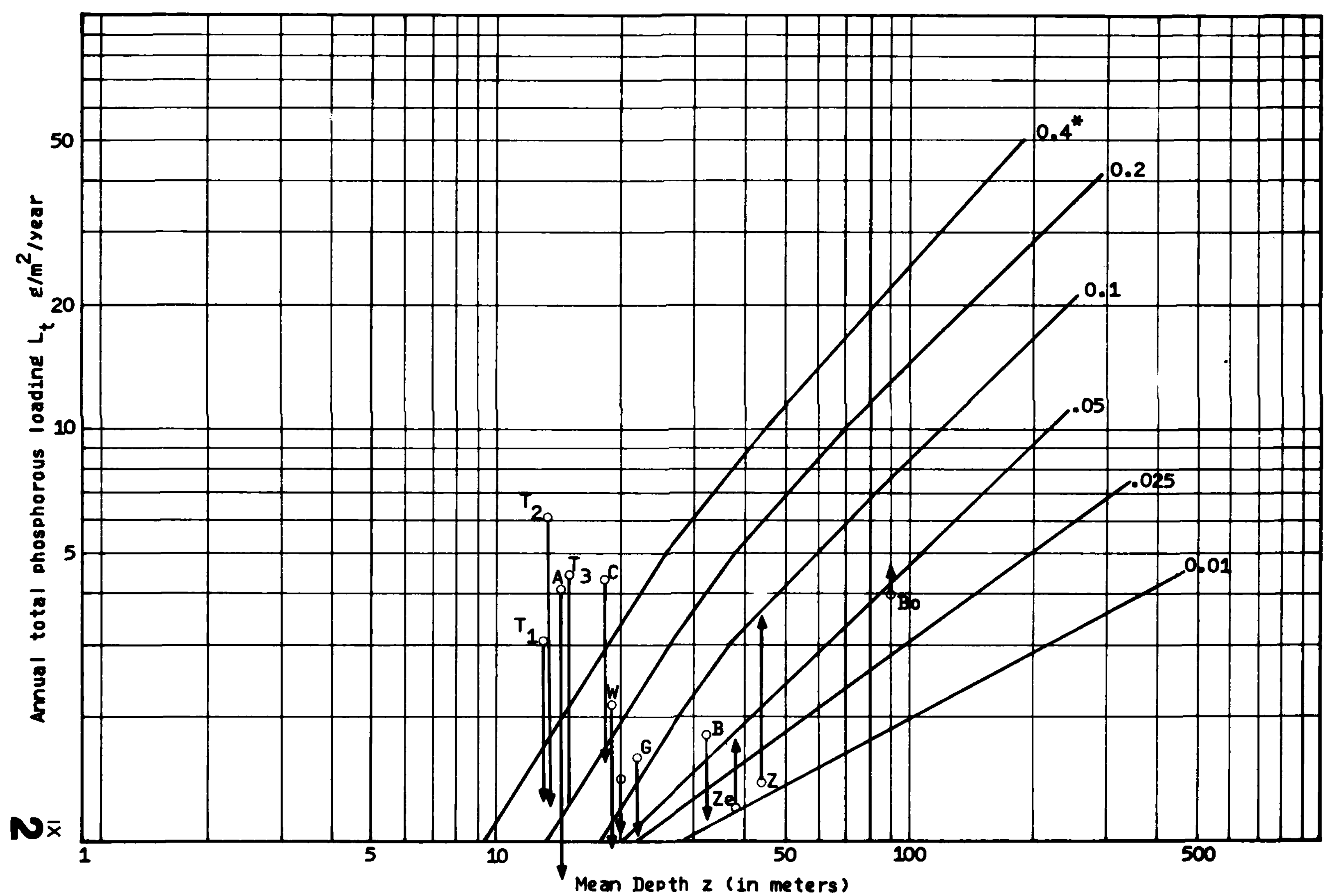
Imboden's plot has been redrawn to the new criteria in Figure 9-2.

Figure 9-2 and Table 9-1 indicate that even with the revised criteria, Tocks Island Lake will exceed the "permissible limit." The lakes used by Imboden in the original figure that remained on scale after the new criteria were applied, are also shown for perspective. Cannonsville, Wahnbach and Allegheny are all again correctly predicted as being quite eutrophic and Tocks Island, applying WAPORA's conservative value for L_t and both Fuhs and Allen's (1974) measurements, falls within the same general grouping as these three.

The implication of this analysis is that Tocks Island Lake will probably show more severe signs of eutrophy than the criteria set. That is,

the reduction in dissolved oxygen experienced in the hypolimnion during summertime stratification will probably exceed 5 mg/l. If the reduction of dissolved oxygen beyond the criteria is in direct proportion to the phosphorus loading rate (which is indicated by Imboden's equations), then the reduction could be as high as 5 mg/l x 3 or 15 mg/l; that is, the dissolved oxygen in the hypolimnion may be completely exhausted toward the end of the stagnation period.

It must be emphasized here that (1) this prediction goes far beyond the original basis of the model and (2) the model does not take into account the shape of the lake which, as will be discussed later, may ameliorate any tendency toward low dissolved oxygen levels.



Imboden's Model Redrawn to New Criteria.

IX.A.3(c) The Dillon Model and Prediction of Transparency in Tocks Island Lake

Significant advances have been made in the past few years in the application of holistic models to the prediction of trophic states in lakes. Studies by Vollenweider (1968) and by Imboden (1974) introduced the concept that the tropic state of a lake could be quantitatively related to the phosphorus loading rate, the mean depth, and some measure of the flushing rate. As indicated in Section IX.A.3, application of the Imboden model, which was derived in part from Vollenweider's work, indicates that the proposed Tocks Island Lake will probably show significant eutrophy based upon a recalculation of Imboden's curves (assuming less stringent criteria for the measurement of eutrophy). The application of this revised model indicates that the hypolimnion of Tocks Island Lake will experience a greater than 5 mg per liter reduction in dissolved oxygen concentration following a period of stagnation of up to 90 days.

A different application of the same concept has been proposed and developed in papers recently published by Dillon (1975) and Dillon and Rigler (1974). The authors incorporated another variable, the retention of phosphorus by lake sediments, into the model. This helps to make the model more realistic than any yet proposed. The essence of the model is contained in an equation relating the total phosphorus

concentration in the lake water at spring overturn to the loading rate, the retention factor, the mean depth, and the flushing rate. The equation is as follows:

$$P = \frac{L\ (1-R)}{\bar{z}\rho}$$

where P equals the mean phosphorus concentration in grams per cubic meter, L is the phosphorus loading rate in grams per square meter per year, R is the retention coefficient determined experimentally as described below, ($\bar{z}$) is the mean depth of the lake in meters, and ρ is the flushing rate in times per year. The retention coefficient, R, is a measure of the fractional loss of phosphorus from the water to the sediment as the water travels through the impoundment and is expressed by:

$$R = 1\,\frac{\bar{z}qo[Po]}{\bar{z}qi[Pi]}$$

where the numerator and denominator indicate the total mass of phosphorus leaving the reservoir and the total mass of phosphorus entering the reservoir respectively each year. R is the fraction of phosphorus entering the reservoir that is permanently retained by sediments and plant life.

The model was tested by the authors on 13 southern Ontario lakes. The lake parameters necessary to test the model are shown in Table 9-2. The flushing rate, phosphorus loading rate, and retention times for 1971 and 1972 were determined experimentally and the measured and predicted phosphorus concentration in the lakes at spring overturn were compared as shown in Table 9-3. The correlation coefficient between the observed values and the predicted values listed in the column labeled 1972[a] was 0.90 excluding Talbot Lake. The correlation coefficient between the observed values and the predicted values listed in the column labeled 1973[b] was 0.85 excluding Talbot Lake. In Table 9-3 the mean difference between observed and predicted values is positive in both series and is significantly different from zero as determined by a Student "t" test. The mean difference between the observed and 1972 predicted column was 1.28 and had a Student "t" of 2.9. The mean difference between the observed and the 1973 predicted values was 1.99 with a student "t" of 3.1. Thus, while the predicted phosphorus concentrations compare reasonably well with the observed concentrations in the 13 Southern Ontario lakes, there appears to be a significant systematic difference between them, with the observed values being 14 to 22 percent higher than the predicted values.

The comparison between observed and predicted phosphorus concentrations was also performed for 4 oligo-mesotrophic and 4 eutrophic lakes described by Vollenweider (1969). This comparison is shown in Table 9-4. The comparison between observed and predicted phosphorus concentrations appears to be rather good for the oligo-mesotrophic

Table 9-2 The flushing rate (ρ), total phosphorus loading rate (L), and total phosphorus retention coefficient (R) for 13 Southern Ontario Lakes.

Lake	$\rho(yr^{-1})$		$L(mg\ m^{-2}\ yr^{-1})$		R	
	1971	1972	1971	1972	1971	1972
Cameron	13.8	18.9	1700	2210	0.38	0.30
Four Mile	0.21	0.26	108	107	0.85	0.82
Raven	12.2	14.9	200	217	0.56	0.55
Talbot	-	4.9	-	98	-	0.69
Bob	0.30	0.37	153	162	0.75	0.71
Twelve Mile-Boshkung	1.87	2.38	311	352	0.40	0.33
Halls	0.83	0.96	194	217	0.53	0.53
Beech	16.8	22.7	1360	1680	0.05	0.07
Maple	5.9	8.0	803	860	0.37	0.26
Pine	16.3	18.5	1050	1060	0.04	0.01
Cranberry	55.7	62.7	1320	1280	-0.02[a]	-0.07[a]
Eagle-Moose	1.82	2.03	217	232	0.27	0.36
Oblong-Haliburton	-	0.32	-	124	-	0.72

Source: Dillon, P.J. & F.H. Rigler, 1974. A test of simple nutrient budget model predicting the phosphorus concentration in lakewater. Contrib. No. 5 from the Canadian Shield Research Project, Canada Centre for Inland Waters.

[a]Although it is possible to have a negative retention coefficient on a short term basis because of loss of materials from the sediments, these figures more likely reflect the experimental error associated with these budget calculations.

Table 9-3 Measured [P] and predicted ($L(1-R)/\bar{z}\rho$) total phosphorus concentration at spring overturn in 13 Southern Ontario Lakes.

Lake	[P] (mg m^{-3})	$L(1-R)/\bar{z}\rho$ (mg m^{-3})	
	1972	1972[a]	1973[b]
Cameron	12.4	10.8	11.5
Four Mile	12.0	8.3	8.0
Raven	8.3	9.9	9.0
Talbot	15.3	-	7.3
Bob	8.5	7.1	7.0
Twelve Mile-Boshkung	6.1	5.4	5.4
Halls	4.3	4.0	3.9
Beech	8.5	7.8	7.0
Maple	9.3	7.4	6.8
Pine	10.5	8.4	7.7
Cranberry	9.9	6.9	6.2
Eagle-Moose	7.1	6.8	5.7
Oblong-Haliburton	5.3	-	6.1

Source: Dillon and Rigler (Ibid).

[a] Budget measured from May 1971 - April 1972.

[b] Budget measured from January 1972 - December 1972.

Table 9-4 Total phosphorus budget data for 8 Swiss lakes. (From Vollenweider 1969).

Lake	[P] (mg m^{-3}) at spring overturn	L (mg m^{-2} yr^{-1})	R	$\bar{z}$ (m)	ρ (yr^{-1})	$(L(1-R)/\bar{z}\rho$ (mg m^{-3})
oligo-mesotrophic						
Aegerisee	7.6	160	0.68	49	0.115	9.1
Türlersee	14.5	300	0.80	14	0.465	9.2
Hallwilersee	40	550	0.36	28	0.260	48.4
Zurichsee-Untersee	32	1320	0.25	50	0.680	29.1
eutrophic						
Bodensee-Obersee	115	4065	0.65	100	0.205	69.4
Pfäffikersee	88	1360	0.77	18	0.385	45.1
Greifensee	118	1565	0.62	19	0.490	63.9
Baldeggersee	162	1750	0.61	34	0.220	91.2

Source: Dillon and Rigler (Ibid).

lakes, but the same comparison for the eutrophic lakes is poor. For the eutrophic lakes only, the ratio of the observed to the predicted phosphorus concentrations ranges from 1.65 to 1.95, with a mean of 1.8. The ratios are surprisingly constant, varying only 8 percent about the mean, whereas the observed and predicted phosphorus concentrations themselves vary over a factor of 2. This observation suggests that there are processes in eutrophic lakes unaccounted for in the model, and that these processes are internally consistent in dimension.

The Dillon model resolves one of the serious drawbacks of the Imboden (1974) model, namely, that the lakes used to verify the latter all had flushing times much longer than that expected for Tocks Island Lake. As shown in Table 9-2, the flushing rate of lakes used to verify the Dillon model ranged from .21 per year to 56 per year, which covers the range of expected flushing rates for Tocks Island Lake of 4 to 8 per year. Another relevant point is that the Dillon model is verified with lakes located in the Canadian Shield, an area not far different in climate, geology, and predominating soil types from the area of the proposed impoundment. The Dillon model has the added benefit that it relates the phosphorus loading, flushing rate, retention coefficient and mean depth to a springtime phosphorus concentration that can be transformed into a number which most laymen can understand as transparency. This overcomes the difficulty with the Imboden and

Vollenweider models in that they merely indicated a phosphorus loading rate above which there was a high degree of eutrophy.

The total phosphorus concentration at the time of spring overturn has been related to the summertime average chlorophyll a concentration by Dillon and Rigler (1974). The regression equation developed from 46 observations of the summertime chlorophyll a concentrations and the total phosphorus concentration at spring overturn was:

$$\log_{10} [\text{chl } \underline{a}] = 1.449 \log_{10} [P] - 1.136$$

The correlation coefficient is 0.95.

Carlson (1974) recently completed a study on the relationship between chlorophyll a concentrations and Secchi Disk readings. The Secchi Disk is a white disk which is lowered into a lake and the depth at which it disappears is known as the Secchi Disk Transparency or Secchi Disk reading. The Secchi Disk reading is a measure of the transparency of the surface waters and, in lakes that are not highly colored or experiencing active silt loading at the time of the observation, can be considered a measure of phytoplankton or chlorophyll a concentrations. The log - log regression equation developed by Carlson from 147 data points had a correlation coefficient of 0.93. The equation transformed to linear form is written

$$SD = 7.7 \frac{1}{\text{chl}^{0.68}}$$

where SD is the Secchi Disk reading in meters, and chl is the chlorophyll _a_ concentration in milligrams per cubic meter.

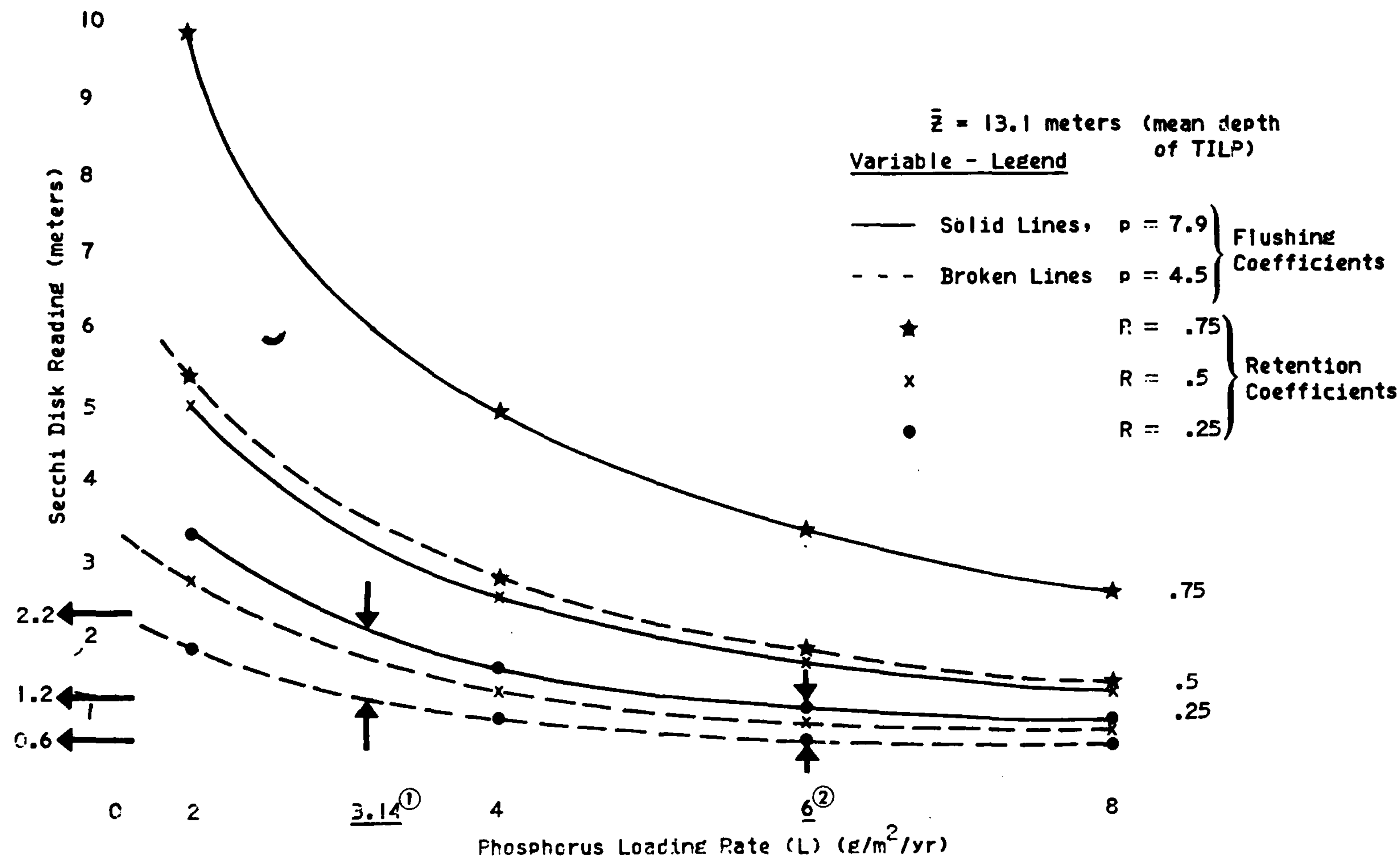
The Dillon model for phosphorus concentrations in lakes at the time of spring overturn, combined with the transformations to chlorophyll _a_ concentrations by Dillon and Rigler (1974) and the transformation of chlorophyll _a_ concentrations to Secchi Disk readings by Carlson (1974) can be applied, using existing data, to predict the transparency of the waters of the proposed Tocks Island Lake. The major unknown was the retention coefficient, R. The retention coefficient for Cannonsville reservoir is roughly 0.5 according to data published by Hull (1975). The slower flushing eutrophic Swiss lakes have retention coefficients somewhat higher, 0.61 to 0.77 as shown in Table 9-4. Coefficients may range from nearly zero for an extremely fast flushing lake to .85 for a very slow flushing lake.

Fuhs and Allen (1975) calculated flushing rates for Tocks Island Lake of 7.9 per year at pool elevation of 410 feet, 5.1 per year at maximum pool and an average of 4.5 per year through the summer months, June through September. These values bracket an acceptable range of flushing coefficients to consider in applying the Dillon model.

Figure 9-3 shows the relationship between phosphorus loading rate to Tocks Island Lake and the summertime Secchi Disk reading calculated using the Dillon model over a range of retention coefficients from

.25 to .75 and a range of flushing coefficients from 4.5 per year to 7.9 per year. The range of phosphorus loading values published to date is 3.14 grams per square meter per year determined by WAPORA (1972) to 6.0 grams per square meter per year determined by Fuhs and Allen (1975). The range of expected Secchi Disk readings (assuming a retention coefficient of about .3) as a function of flushing rate for the two extreme estimates of phosphorus loading rate are indicated by arrows. For the lower phosphorus loading rate the range is 1.2 to 2.2 meters. For the higher phosphorus loading rate, the range is .6 to 1.2 meters. The four points indicated by arrows bracket the range of Secchi Disk readings predicted by the model. The data by Fuhs and Allen (1975) is considered to be the more reliable. Thus, we expect the phosphorus loading rate to be much closer to 6.0 grams per square meter per year. The model then suggests that transparency will be 0.5 to 1.2 meters in the lake during the summer.

It should be noted that in developing the model for Tocks Island Lake, the correction factor of approximately 1.8 suggested by the analysis of observed and predicted phosphorus concentrations in eutrophic Swiss lakes as shown in Table 9-4 was not applied. A more accurate estimate of phosphorus concentrations expected in Tocks Island Lake would include this factor. That is, a phosphorus concentration determined from Equation 1 should be multiplied by some factor between 1 and 1.8 to take account of an apparent systematic error between predicted and observed phosphorus concentrations. Since it was clear from the



①Phosphorus loading value as determined by WAPORA (1972)
②Phosphorus loading value as determined by Fuhs and Allen (1974)

3 $\bar{x}$

foregoing analysis that Secchi Disk readings would be quite low, however, and additional phosphorus concentrations would not decrease the Secchi Disk reading by a very large amount, the correction factor was not included.

IX.A.3.(d) Criticisms

The model does not take into account the shape of the lake. None of the models that have been applied prior to this report, nor the Dillon model, have taken into account the fact that the lake is almost 80 times as long as it is wide, and that the hydrology of the lake will probably be different from virtually every lake used to verify the predictive models that have been applied to Tocks Island Lake. The major problem with holistic models such as Imboden's and Dillon's is that they must consider the whole lake rather than parts of it.

There appears to be a systematic error in the predicted phosphorus concentrations in the 13 lakes in Southern Ontario. The predicted phosphorus concentrations appear to be low by 14 to 22 percent over the observed phosphorus concentrations. This correction applied to the predicted Secchi Disk transparencies in the proposed Tocks Island Lake would make the predicted readings even smaller, however, the apparent systematic error, if corrected in the model applied to Tocks Island Lake, would favor a high degree of eutrophy.

IX.A.4 POINT AND NON-POINT SOURCES OF TOTAL PHOSPHORUS IN THE UPPER DELAWARE RIVER BASIN

The purpose of this section is to evaluate the relative contribution of total phosphorus to the surface waters of the Delaware River in the upper Delaware River Basin (DRB drainage basin contributions to main-stem flow at Montague, see description VI.A.1.a) from point and non-point sources. This analysis will indicate phosphorus sources that have the greatest potential impact upon Tocks Island Lake.

In this analysis, a number of assumptions and qualifications were required. These are discussed below along with a discussion of the sources of data.

IX.A.4(a) Sources of Data and Loading Factors - Point Sources

The contribution of total phosphorus was estimated from the discharge from known point sources in the study area as compiled in two references: (1) a special study by the State of New York locating point sources of treated wastewater and (2) Water Quality Management Plan, 1974, from the DRBC listing an inventory of point sources from resorts in the upper basin. No comparable data could be located for the Pennsylvania portion of the upper Delaware River basin. Thus, this analysis considers New York only.

Total phosphorus loading in either treated or untreated wastewaters were taken from the Handbook of Environmental Control and from Wastewater Treatment by Metcalf & Eddy (1972). Table 9-5 shows the typical concentrations of waste constituents in influent sewage and Table 9-6 shows estimated pollutant removal efficiencies for different types of treatment. In most cases, it was assumed for evaluation purposes that influent sewage was of "Medium" strength. Both primary and conventional secondary treatments of all kinds effect only a 5-10 percent removal of total phosphorus. Thus in most calculations, a total phosphorus concentration of 9 or 10 mg/ℓ in the effluent was assumed. In some cases, as when the influent water contained heavy loads of industrial or farm wastes, an influent strength of "Heavy" was assumed.

Insufficient data were available to determine the actual operating characteristics of each treatment plant on a day-to-day basis. The only information of this kind available consisted of a notation in the source document if the facility was presently overloaded. Therefore, it was necessary to use the figure for design flow in calculating phosphorus loading. A number of the treatment facilities are thought to receive substantial volumes from infiltration in wet weather and it is likely that at these times the facilities are overloaded. In general, most facilities operate the majority of the time at below design flow.

Table 9-5. Typical Strength of Influents

	mg/ℓ			
	BOD	SS	TOTAL N	TOTAL P
Strong	300	500	85	20
Medium	200	300	50	10
Weak	100	100	25	6

Source: Wastewater Treatment, by Metcalf and Eddy, 1972.

Table 9-6. Estimated Removal Efficiencies for Wastewater Treatment Processes

TREATMENT	PERCENT REMOVAL				
	SS	BOD	COD	TOTAL P	TOTAL N
Conventional Secondary	90	90	80	10	50
Primary	40-70	25-45		5	5
Coag-Sed.	99	93		95	50

Source: Handbook of Environmental Control, Volume IV, Bond, Richard G., and Conrad P. Straub, CRC Press, 1974.

The State of New York has recently imposed restrictions on the sale of detergents containing phosphates. The effectiveness of its implementation and its effect upon total phosphorus loads in influent have not been evaluated. Estimates of the total phosphorus reduction vary widely but a figure of 50-60 percent has been predicted and observed in other states that have imposed similar restriction (J. Shapiro, personal communication, April 1975). This has not been taken into consideration in the calculations that follow. The potential effect of the present ban will be discussed later.

Only point source wastewater discharged to surface flows are allowed to leak into surface waters (as septic tanks that leak to rivers or streams) were considered. Septic tanks where the drainage is completely absorbed in the land were eliminated.

An effort was made to align small discharges listed in the DRBC report with receiving watersheds. The annual phosphorus loading at each plant is the Product Annual Flow x Estimated Influent Phosphorus Concentration x (1 - Removal Efficiency).

IX.A.4(b) Sources of Land Use Data and Total Phosphorus Loading Factors - Non-Point Sources

Land use data usable in approximating total phosphorus loads from non-point source drainage was available from the Land Use and Natural Resource

(LUNR) study only for the portion of the upper Delaware River basin within the State of New York. No data could be located that contained sufficient detail for our uses in Wayne and Pike counties, Pennsylvania. Thus the non-point contribution to the Lackawaxen River could not be considered in detail in this evaluation but has been grossly estimated toward the end of this discussion. The COWAMP Study presently underway by Roy F. Weston Asso. and Betz Environmental Engineering for the State of Pennsylvania is designed to answer these specific questions.

Pollutant loading functions from non-point sources were taken from a recent paper by Loehr (1974) in which he reviewed several diverse sources of data. He was able to classify land use activities into six broad but distinctly important categories. Loehr (1974) summarized his study in a table showing the ranges of non-point loadings from the six land use types and from rainfall. A portion of this summary is shown in Table 9-7.

In order that the best available single loading values be used in the non-point source evaluation, Loehr's original data was consulted, and the actual data obtained in climatic areas most like northeastern Pennsylvania was used in calculating loading factors. Data on pollutant loading functions collected at random from several studies is distributed log normally rather than normally. A log normal distribution has the property that the logarithmic mean is closer to the median than is the arithmetic mean. In these cases the log-mean

Table 9-7. Non-point Source Characteristics - Summary

	AREA YIELD RATE kg/YEAR/HECTARE		
	NO_3-N	TOTAL N	TOTAL P
Precipitation	1.5-4.1	5.6-10	.05-.06
Forested land	.7-8.8	3-13	.03-.9
Range land	0.7	---	0.08
Agricultural Cropland	---	0.1-13	.06-2.9
Land Receiving Manure	---	4-13	.8-2.9
Urban land	---	7-9	1.1-5.6
Feedlot	---	100-1,600	10-620

Source: Loehr, R.C. 1974, Characteristics & Comparative Magnitudes of Non-point Sources, JWPCF 46(8):1849-1872.

is a better measure of central tendency than the arithmetic mean and should be used as the measure of the loading factor. Table 9-8 shows the means or log-means of data summarized by Loehr (1974) from selected representative areas of the United States. Footnotes indicate whether the value reported is an arithmetic or logarithmic mean. The judgment as to which mean to use was based upon inspection of the distribution of the data set.

The DRBC made use of loading factors developed by Haney (1973) in a study reported internally by SUNY-Binghamton, to estimate total phosphorus loading to the Delaware River from the New York portion of the upper basin. The loading values used by the DRBC and those developed here from Loehr's data are compared in Table 9-9. The agreement between the URS and the DRBC factors is excellent for forested land and agricultural cropland. Agreement between urban area values and pasture values is poor. In the latter two cases, the DRBC's values are lower than the minimum values found by Loehr in the entire United States, suggesting that these values may not be representative of the actual contributions to runoff pollution from these sources. URS utilized those taken from Loehr (1974) for the evaluation of non-point sources.

IX.A.4 (c) Methodology

Point Sources

The characteristics of point sources for wastewater in the New York

Table 9-8 Selected Non-point Source Yields from Representative Areas of the United States

LAND USE AND STUDY AREA	AREA YIELDS IN kg/YEAR/HECTARE		
	NO_3-N*	TOTAL-N+	TOTAL-P
Forested Land (Minn., Ohio, N.H.)	1.9_1	1.7_1	$.047_2$
Agricultural Cropland (Midwest & N.C.)	1.7_2	6.1_2	0.47_2
Pasture (Wisc., N.C.)	2.3_2	8.5_2	1.7_2
Feedlots (Nebraska)	--	540_1	75_2
Urban Areas (Northeast, Midwest)	1.3_2	7.8_1	2.7_1

* As NO_3

\+ As N

1. Arithmetic mean

2. Logarithmic mean

Source of Data: Loehr, R.C. 1974. Characteristics and Comparative Magnitude of Non-Point Sources, J. Wat. Poll. Control Fed. 46(8): 1849-1972.

Table 9-9. Comparison of Non-point Source Loading Factors Developed by URS and Those Used by the DRBC

LAND USE	YIELD IN kg/HECTARE/YEAR	
	TOTAL-P (URS)	TOTAL-P (DRBC)
Forested Land	0.047	0.049
Agricultural Cropland	0.47	0.40
Pasture	1.7	.17*
Feedlots	75	--
Urban Areas	2.7	.91*

*Values below the minimum reported for the entire United States by Loehr (1974).

portion of the basin were recorded. Design flows were used in most cases; however, in a few cases, average actual flows were known and utilized when existing. Table 9-10 notes where actual flow was used. After conversion to proper units, total phosphorus load was calculated as the product.

$[1{,}380 \text{ kg P year}^{-1} \text{ MGD}^{-1} (\text{mg}/\ell)^{-1}] \times$ Flow (MGD) $\times$ Total Phosphorus Concentration in Effluent (mg/ℓ).

Control of sewage sources means control of available phosphorus.

Numerous small housing units or resorts serviced only by septic tanks or sand filters were added together and handled as a single discharger providing primary treatment.

Non-Point Sources

The LUNR Study reported land uses and areas devoted to those uses by township as demonstrated in Table 9-11. URS reclassified the reported uses, as shown in Table 9-11, for the purposes of applying the non-point pollution yield figures from Loehr (1974). Control of non-point sources means control of partly available phosphorus.

The active agriculture category was subdivided into cropland, pasture and poultry acreage. From the number of dairy farms, poultry farms and other farms from the LUNR Study, the study team assumed that dairy and other farms (probably vegetable, truck farms or mixed purpose farms) were of equal size and poultry farms were roughly one-fifth as large since much less area is required for chicken rearing. The total

Table 9-10 Estimate of Point Source Contributions

Source	Treatment	BOD Removal(%)	Design Flow MGD	Effluent Total Phosphorus Concentration mg/ℓ	Annual Total Phosphorus - kg	Comments
WEST BRANCH DELAWARE						
Stamford	A	35	0.4	10	5530	
Hobart	P/SS		.075	10	1040	Probably surface flow in winter
Parnel Packing (Bloomville)	A	85	.02	10	276	
Delhi	TF	90	.52	9	6470	BOD removal efficiency overstated
Middletown Milk & Creamery, Delhi	Sp		.32	10	4420	Probably surface flow in winter
Walton	TF/C	96	1.17	.5	810	Proposed--will be used in this est.
Breakstone Foods						combined with Walton
Deposit	Se		.3	9	3730	
Hancock	N		.3	10	4150	
EAST BRANCH DELAWARE						
Fleischmanns	I/Se		.07	9	870	Summer residents only-discharge avgd.
Livingston Manor	TF	67	.35	18	8700	Strong influent from poultry farm
Roscoe	IT		.09	10	1240	
DELAWARE MAIN STEM						
Calicoon	P		.1	10	1380	
Narrowsburg	P		.1	10	1380	
Berryville	P		.11	10	1520	Flow calculated from the population
All other discharges on Delaware	P		1.13	10	15,610	
Total phosphorus on Delaware					57,210	kg/year
MONGAUP RIVER BASIN						
Liberty	TF	90	1.8	9	22,380	BOD removal efficiency overstated
Swan Lake	T	95	1.0	.5	691	Includes Loomis & White Sulphur Spgs
Hurleyville	T	95	.24	.5	166	
Kauneonga	TF	83	.6	9	7,460	
Smallwood	TF		1.0	9	12,440	Proposed but included here

Table 9-10 Estimate of Point Source Contributions (continued)

Waste Source	Treatment	BOD Removal (%)	Design Flow MGD	Effluent Total Phosphorus Concentration mg/1ℓ	Annual Total Phosphorus - kg	Comments
Sachett Lake	TF	85	.5	9	6,220	
All other discharges on the Monguap	P		.78	10	10,780	
Total Phosphorus on Monguap					60,130	kg/year
NEVERSINK RIVER BASIN						
Woodborne	Se		.2	9	2,490	
Woodborne Rehab. Center	TF	85	.2	9	2,490	
So. Fallsburg	TF	85	1.2	9	14,920	BOD removal efficiency overstated
Fallsburg-Woodborne	TF	85	2.4	9	29,840	Proposed to take over Woodborne, Woodborne Rehab. & So. Fallsburg
Port Jervis	TF	85	2.5	9	31,100	BOD removal efficiency overstated
Lock Sheldrake Pk	I/SF	75	.05	10	690	
Lock Sheldrake	TF	90	.27	9	3,360	BOD removal efficiency overstated
Kiamesha	TF	85	.6	9	7,460	BOD removal efficiency overstated
Monticello	TF	85	2.0	9	24,870	BOD removal efficiency overstated
Monticello	AS	95	6.0	9	74,610[1]	Proposed--will not be at full capacity
Lake Louise Marie	A	85	.06	9	750	Design flow 0.6--actual flow shown
Melody Lake	A	85	.01	9	125	Design flow 0.04--actual flow shown
Other discharges in Neversink	P		1.42	10	19,620	

Present Total Phosphorus on Neversink 107,875 kg/year
Future Total Phosphorus on Neversink 167,555 kg/year
Present Total Phosphorus discharged in New York portion of Delaware Basin from point sources . . . . . . 225,215 kg/year

Future total phosphorus discharged in New York portion . . . . . . 284,895 kg/year

[1]Facilities replace phased out plants. These used in calculation of future loads.

FOOTNOTES - ABBREVIATIONS FOR TREATMENT

A	-	Aeration in lagoons
P	-	Primary Treatment
SS	-	Subsurface disposal
TF	-	Trickling filter
Sp	-	Spray irrigation
N	-	No treatment at present
Se	-	Septic tanks
C	-	Coagulation
IT	-	Imhoff Tank
T	-	Unspecified tertiary
I	-	Intermittent use
SF	-	Sand filter
AS	-	Activated sludge
CS	-	Conventional secondary

Sources: DRBC, Water Quality Management, 1974.
(Inventory of point and non-point sources)

Table 9-11. Land Uses from the LUNR Study and Their Reclassification by URS for this Study Township of Bethel

TYPE OF USAGE	SQUARE MILES	URS RECLASSIFICATION
Active Agriculture	9.85	Agricultural Cropland Pasture & Dairy Farm Poultry Farms
Woodlands		
Forest	40.34	Forest Land
Brushland	18.13	
Wetlands	5.77	excluded
Water	4.70	excluded
Residential		
High Density	0.0	
Medium Density	1.24	Urban
Low Density	.19	
Other	.43	
Commercial	1.70	
Industrial	0.0	
Extractive	.19	
Public and Semi-Public	.22	excluded
Outdoor Recreation	1.56	Forest
Transportation	.16	Urban
Non-productive	5.05	Urban

agricultural area is represented by the formula:

$$\text{Total Area} = DF(x) + OF(x) + .2(PF)\ (x)$$

where DF, PF and OF represent the numbers of dairy, poultry and other farms respectively and X represents the average area of a dairy or other farm. The area X was first calculated then the total acreage allotted to each type of farming was calculated using each respective coefficient of X in the formula above. Other farm acreage was handled as feedlots since they usually represent areas of high concentration of fecal wastes. This scheme makes several assumptions about relative sizes of farms that are difficult to document but lacking more comprehensive data, there is little improvement that can be made at present.

Poultry farms are treated as feedlots and dairies as pasture land that receives manure. Dairy farms are under fairly intensive grazing pressure and probably contribute more nutrient runoff than the log-mean value obtained from Loehr for pasture land, although this was not quantifiable. Area loading factors for urban areas were determined primarily from runoff from highly urbanized areas. The cities and towns of this portion of New York State should not be described as heavily urbanized but rather as residential. The actual loading factors may be somewhat lower than those used here. On the other hand, larger cities tend to have street sweeping programs while smaller towns cannot afford them. This would tend

to raise area loading factors. We have assumed here that urban area loading factors are represented by the number given in Table 9-8 and that smaller size and general lack of sweeping programs cancel one another in effect.

Woodlands, public lands and outdoor recreation lands were lumped together as forested land. All residential, commercial, industrial, transportation and non-productive land was lumped together into the urban area category.

Non-productive land was assumed to be urban vacant lots rather than rural land. URS's experience in three major studies of non-point source runoff has been that pollutants coming off an urban watershed may be very closely approximated by pollutants coming off the streets only. (URS - A Manual for Water Quality Management Planning for Urban Runoff, 1974; URS - Toxic Materials Analysis of Street Surface Contaminants, 1973.) Thus, non-productive land will be treated as urban for the purposes of this analysis.

Wetlands and water were excluded since they are receivers of runoff rather than sources. The single exception is that wildfowl contribute quantities of total phosphorus. This contribution could not be evaluated with the present data. Extraction lands were excluded since they should be considered point sources whenever they occur.

Most of the townships lay completely within the borders of the upper basin. For those that lay across a boundary line, the area within the basin was approximated to the nearest tenth. As a check to our determination, the sum of areas estimated was compared with the areas given by the DRBC in Water Quality Management Plan. Our totaled estimates were high by about 2 percent, not a significant error. In townships that were so fractionated, land uses were divided equally as though all of the land use functions were homogeneously distributed throughout the township area.

After areas were transformed from square miles to hectares (259 hectares/square mile), loadings were assigned and total loads of total phosphorus calculated by township.

IX.A.4(d) Results

Point Sources

The estimate of point source contributions is shown in Table 9-10. Both present and future loads are shown. Future plans include replacing three plants in the Woodborne area with a single plant serving Fallsburg - Woodborne (State-County), and to replace the present Monticello (State-County) facility that is periodically overloaded, with a new plant. Actual flow values and total annual phosphorus loads were calculated from the design flow. Thus, the study estimate of future loads is considered high, and the estimate of present loads is low because some present-day plants are overloaded and some future plants will be operating below capacity.

The present load of phosphorus from plant sources is about 225 metric tons/year, 48% of which is contributed in the Neversink, the Woodborne area, Port Jervis, Monticello and individual septic tanks. The future load is estimated at about 285 metric tons, of which 59% will come from the Neversink River Basin. The increase in estimated load comes exclusively from the Woodborne area and Monticello.

It is instructive to consider the total impact of implementing 95% phosphorus removal technology to the four largest treatment plants in the basin: Liberty, Fallsburgh-Woodborne (proposed), Port Jervis and Monticello. The results are shown in Table 9-12. The total annual phosphorus load from point sources in the New York portion of the basin could be reduced to nearly one-half of the projected levels using the technology presently being considered as economically and technically feasible under Public Law 92-500.

Non-Point Sources

The estimated contributions to total annual phosphorus loads from non-point sources are shown in Table 9-13, and summarized in Table 9-14. The percentage contribution of each land use type to total area and total phosphorus loads is given in Table 9-14. Forest and brush lands account for 81% of the total land but only 10% of the total phosphorus while urban areas, pastures and feedlots account for only 11% of the land but 87% of the total phosphorus load. Thus, the total estimated non-point load is about 244 metric tons per year, compared with 225 metric tons/years from point sources. Point and non-point contributions are estimated to be approximately equal.

Table 9-12 Impact of 95% Removal in the Four Largest Existing Plants on Total Phosphorus Loads Entering the Mainstem at Montague, N.J.

PLANT	PRESENT TECHNOLOGY	95% REMOVAL
	kg/year	
Liberty	22,380	1,244
Fallsburgh-Woodborne	29,840	1,658
Port Jervis	31,100	1,727
Monticello	74,610	4,145
Totals	157,930	8,774

Total future loads from all point sources

Without 95% phosphorus removal	285 metric tons/year
With 95% phosphorus removal on the above four plants	136 metric tons/year

Table 9-13 Estimated Contributions to Total Annual Phosphorus Loads From Non-Point Sources

DELAWARE COUNTY			SURFACE WATER		EXTRACTIVE		NON-INTENSIVE USE FOREST, BRUSH, OPEN		contribution	URBAN	total contribution	PASTURE	total contribution	FEEDLOT POULTRY	total contribution	AGRICULTURE	total P
TOWNSHIP	mi^2	hectares	mi^2	hectares	mi^2	hectares	mi^2	hectares	P kg/yr (hx.047)	hectares	P kg/yr (hx2.7)	hectares	P kg/yr	hectares	P kg/yr (hx75)	hectares	kg/yr (hx.47)
ANDES	111.36	28,842	3.80	984	.05	12.9	87.69	22,711	1,067	650	1,755	2,121	3,520	-	-	2,323	1,092
BOVINA	43.89	11,367	.28	72	-	-	33.01	8,549	402	331	895	2,175	3,610	-	-	310	146
COLCHESTER	142.20	36,829	5.57	1,442	.13	33.7	130.10	33,695	1,584	787	2,126	352	584	5.18	388.5	538	253
DELHI	63.10	16,342	.53	137	.07	18.13	42.89	11,108	522	974	2,629	3,626	6,019	-	-	528	248
DEPOSIT	44.77	11,595	1.69	437	.05	12.9	36.22	9,380	441	725	1,958	777	1,289	5.18	388.5	249	117
HAMDEN	60.09	15,563	.28	72.5	.07	18.13	41.09	10,642	500	782	2,111	3,501	5,811	-	-	528	248
HANCOCK	170.06	44,045	5.11	1,323	.46	119	154.18	39,932	1,877	1,494	4,035	518	859	5.18	388.5	609	286
MIDDLETOWN	97.0	25,123	.97	251	.05	12.9	79.76	20,657	971	1,087	2,937	1,950	3,237	-	-	1,152	542
ROXBURY	87.29	22,608	1.07	277	.03	7.8	71.95	18,635	876	1,538	4,153	1,901	3,155	23.31	1,748	228	107
STAMFORD	49.00	12,691	.10	25.9	.14	36.2	34.29	8,881	417	590	1,594	3,058	5,076	-	-	31	15
TOMPKINS	103.89	26,907	6.37	1,649	.05	12.9	88.53	22,929	1,077	815	2,203	1,398	2,320	2.59	194	337	158
WALTON	97.20	25,174	.88	228	.10	25.9	77.71	20,126	946	922	2,489	3,480	5,776	-	-	396	186
TOTAL		277,086		6,898		310.4		227,245	10,680	10,695	28,888	24,857	41,256	41.44	3,107	7,229	3,398

SULLIVAN CO. TOWNSHIPS		SURFACE WATER	EXTRACTIVE	NON-INTENSIVE FOREST, BRUSH, OPEN		URBAN	total contribution	PASTURE	total contribution	FEEDLOT/POULTRY	cont P	AGRICULTURE	cont P
	area in hectares	hectares		hectares	P(kg/yr)	hectares	P(kg/yr)	hectares	P(kg/yr)	hectares	kg/yr	hectares	kg/yr
BETHEL	23,188	2,711	49.2	15,604	733	2,271	6,132	777	1,289	103	7,770	1,605	755
CALLICOON	12,631	184	2.6	8,974	422	1,199	3,237	940	1,560	80	6,021	1,250	588
COCHECTON	10,375	546	7.8	7,959	374	536	1,447	473	786	23	1,748	857	403
DELAWARE	9,759	331	36.3	6,052	284	199	538	531	881	101	7,575	1,784	838
FALLSBURGH	20,442	1,623	18.1	15,283	718	2,579	6,965	163	270	140	10,489	637	299
FORESTBURGH	14,625	1,015	49.2	13,390	629	163	440	-	-	3	194	41	19
FREMONT	13,994	471	2.6	11,105	522	1,098	2,965	318	528	15	1,165	932	438
HIGHLAND	14,006	846	7.8	12,533	589	520	1,405	10	17	3	194	93	44
LIBERTY	20,808	849	15.5	15,540	730	2,364	6,384	463	769	160	12,043	1,414	664
LUMBERLAND	13,949	1,160	5.18	12,746	586	287	776	-	-	-	-	21	10
MAMAKATING	25,457	1,509	49.21	21,846	1,027	1,530	4,132	186	309	13	971	326	153
NEVERSINK	21,766	1,105	7.77	19,031	894	898	2,426	72	120	15	1,165	614	288
ROCKLAND	24,493	823	28.43	22,038	1,035	1,209	3,265	109	180	-	-	280	131
THOMPSON	22,494	3,118	82.9	16,293	765	2,815	7,601	62	103	44	3,302	78	36
TUSTEN	14,045	839	10.4	12,582	591	391	1,055	26	43	3	194	192	90
TOTAL	262,032	17,110	373	210,956	9,899	18,059	48,768	4,130	6,855	703	52,831	10,124	4,756

Table 9-13 Estimated Contributions to Total Annual Phosphorus Loads From Non-Point Sources (continued)

	AREA IN HECTARES	SURFACE WATER	EXTRACTIVE LAND/HECTARES	NON-INTENSIVE USE: FOREST, BRUSH, OPEN		URBAN		PASTURE		FEEDLOT/POULTRY		AGRICULTURE	
		hectares		hectares	total P kg/yr	area hectares	total P kg/yr	area hectares	total P kg/yr	area hectares	total P kg/yr	area hectares	total P kg/yr
BROOME CO.													
TOWNSHIP													
SANFORD	23,357	303	28.5	18,855	886	2,030	5,482	1,341	2,227	7.7	583	790	371
ULSTER CO.													
TOWNSHIPS													
DENNING	27,454	103	-	27,143	1,275	111	301	-	-	-	-	62	29
ORANGE CO.													
TOWNSHIPS													
MINISINK	6,109	132	10.4	2,530	119	556	1,503	2,100	3,487	13.0	971	767	360
MT. HOPE	7,796	132	20.7	5,392	253	1,113	3,006	518	860	103.6	7,770	518	243
PORT JERVIS	1,566	140	15.5	601	28	600	1,622	88	147	-	-	-	-
TOTAL	15,471	404	46.6	8,523	400	2,269	6,131	2,706	4,494	116.6	8,741	1,285	603
GREENE CO.													
TOWNSHIPS													
HALCOTT	5,957	-	-	5,125	241	303	818	310	516	-	-	96	45
TOTAL, DELAWARE RIVER BASIN	611,357	21,218	758.5	497,847	23,381	33,467	90,388	33,344	55,348	868.7	65,262	19,586	9,202

TOTAL P contribution in kg/yr 243,581

Table 9-14 Summary of Land Uses and Total Phophorus Contributions within the New York Portion of the Upper Basin (in hectares and kg/year respectively)

COUNTY	AREA	SURFACE WATER	EXTRAC-TIVE	FOREST & BRUSH		URBAN		PASTURE		FEEDLOTS		CROP AGRICULTURE	
	Ha	Ha	Ha	Ha	kg/yr	Ha	kg/yr	Ha	kg/yr	Ha	kg/yr	Ha	kg/yr
Delaware	277,086	6,898	310	227,245	10,680	10,695	28,888	24,857	41,256	41	3,107	7,229	3,398
Sullivan	262,032	17,110	373	210,956	9,899	18,059	48,768	4,130	6,855	703	52,831	10,124	4,756
Broome	23,357	303	29	18,855	886	2,030	5,482	1,341	2,227	8	583	790	371
Ulster	27,454	103	-	27,143	1,275	111	301	-	-	-	-	62	29
Orange	15,471	404	47	8,523	400	2,269	6,131	2,706	4,494	117	8,741	1,285	603
Greene	5,957	-	-	5,125	241	303	818	310	516	-	-	96	45
Total Area	611,357	21,218	759	497,847		33,467		33,344		869		19,586	
Total-P					23,381		90,388		55,348		65,262		9,202
% of Total Area	100	3.5	.12	81.4		5.5		5.5		.14		3.2	
% of Total - P					9.6		37.1		22.7		26.8		3.8

Total - P 243,581 kg/year

Phosphorus Loads to Tocks Island Lake

The exercise of determining point and non-point source loads of total phosphorus indicates the relative contributions only. The estimates are not equal to the total phosphorus entering the proposed impoundment because the river and tributaries remove substantial amounts of phosphorus by absorption to suspended and bottom sediments, and by permanent biological uptake. Estimates of total phosphorus loads into the proposed impoundment are best made from studies of total phosphorus concentrations in the river below Montague.

Fuhs and Allen (1974) calculated the total phosphorus input at about 305 metric tons/year. WAPORA estimated the load at about 159 metric tons/year. Both estimates are substantially less than the total load of phosphorus from point and non-point sources in New York alone -- 469 metric tons/year.

Lacking land use and point source data for the Lackawaxan River Basin, no detailed estimate of the total phosphorus load can be made. A gross but useful approximation of this load is possible assuming that the Lackawaxan Basin is about 40% the size of the New York portion of the DRB, and land uses are composed of 80% forest, 6% pasture, 7% crop agriculture, 3% urban and 4% water. Under these assumptions, the total phosphorus load to the Lackawaxen River would be about 82 metric tons/year from non-point sources. Further assuming a fraction from point sources equal in relative magnitude to that in the New York portion, the load

from point sources might be 90 metric tons/year. The total phosphorus load to rivers in the entire upper basin thus may be 640 metric tons/year.

Using this value, Fuhs and Allen's (1974) calculation indicates that about 48% of the total phosphorus load reaches the impoundment and WAPORA's (1972) calculation indicates only 25% of the total phosphorus load reaches the impoundment. These percentages are consistent with general observations on the ability of a river system to remove phosphorus from the water as it travels its course.

Phosphorus cycles cause rapid exchange between sediments, biota and water. Each cycling removes a fraction of the phosphorus to a portion of the sediments which is not readily re-released. This is termed "permanent burial." Even though these sediments may later be washed downstream, the phosphorus contained on them is likely not detected as total phosphorus because (1) the sediments are fairly consolidated and tend to move as bed load rather than suspended load and (2) they tend to move under very high flow conditions which are very difficult to sample properly for any constituent. In actuality, phosphorus losses occur along the entire length of the river system so that phosphorus discharged far upstream has only a remote chance of even reaching the impoundment area. Phosphorus discharged closer to the impoundment area has a much greater chance of reaching the impoundment.

IX.A.4(e) Implications for Phosphorus Control Strategies

The foregoing analyses supports certain strategies for phosphorus control in the Delaware River Basin. The strategies may be guided by the four criteria discussed in the following paragraphs.

Only the largest point sources should be upgraded to remove phosphorus. The four largest existing treatment plants shown in Table 9-12, are well downstream toward the lake. Implementing 95% phosphorus technology in these plants would likely decrease the total phosphorus input to the impoundment significantly because the time of travel to the impoundment area is shorter than the basin average. These discharges are probably now having a disproportionate impact upon total phosphorus concentrations in the River at Montague. Ninety-five percent total phosphorus removal on these plants would decrease the annual phosphorus load from the upper basin (including Pennsylvania) from about 640 metric tons to 490 metric tons, a 23% reduction.

If control measures of any kind are implemented on non-point sources, they should recognize and take advantage of the self-cleansing properties of the rivers. Thus, control measures in the upper levels of the upper basin -- Delaware, Broome and Greene Counties -- should be de-emphasized and control measures in the lower counties -- Sullivan, Ulster and Orange -- should be stressed. Ulster county, because it is heavily forested, already has a relatively low phosphorus contribution.

Controls on urban runoff and poultry and/or cattle feedlot runoff in Sullivan and Orange Counties would yield the largest reductions in total phosphorus loads. These two sources alone account for 116 metric tons of total phosphorus or 48% of the total from the New York upper basin non-point sources and 18% from the entire upper basin phosphorus contributions. They probably have a disproportionately large impact upon total phosphorus concentrations in the Delaware River at Montague because of their proximity. If the total phosphorus loads from these two sources were reduced by 50% the nominal reduction in total phosphorus added to rivers in the whole basin would be about 10% (the actual reduction in total phosphorus reaching the impoundment would likely be a great deal larger).

It is likely that controls on feedlot runoff would be more cost-effective than controls on urban runoff. The reason is that the latter represents an extremely diverse source where as feedlots are concentrated enough to effectively appear as a point source. Frequent removal of accumulated manure can effect a sizeable reduction in total phosphorus runoff. Impoundment of runoff water is effective in controlling total phosphorus from feedlot land. Urban area runoff is difficult and expensive to control effectively. Sweeping programs help but are not a universal panacea. Catchment basins are also helpful but are expensive to construct. Proper use of a catchment basin to remove the bulk of urban-generated pollutants is a major engineering problem. The Cannonsville and Pepacton Reservoirs on the West Branch and East Branch of the Delaware River respectively,

probably intercept most of the phosphorus generated in Delaware County from pasture runoff. These reservoirs contribute phosphorus to the lower basin in controlled releases throughout the summer and early fall but they substantially decrease the phosphorus reaching the river at Montague from agricultural pasture lands in the basins draining into the Cannonsville and Pepacton Reservoirs.

IX.A.4(f) Impact of Implementing Public Law 92-500 on Total Phosphorus Loading

Point Source Control

The amendments to the Water Pollution Control Act (PL92-500) specify best practical and economically feasible treatment of point sources by 1983. The most up-to-date plans for implementing these provisions in the New York State portion of the basin were published in the source document for Table 9-10. This document indicates that phosphorus removal technology is planned only for Walton, and treatment to remove phosphorus is not considered for the four largest treatment plants in the basin. Therefore, the implementation of this provision of the law in New York will probably have no noticible impact upon the point source phosphorus loads to Tocks Island Lake.

Of greater impact are the existing restrictions on the use and sale of phosphate detergents in New York State. If the restrictions are fully effective, the reductions in phosphorus loading to sewage treatment plants and septic tanks could be 50-60%. This alone could reduce the total phosphorus load from all sources from 640 metric tons/year (as

estimated in this study) to 540 metric tons/year, a 16% decrease from the total phosphorus load. This estimate assumed that similar measures would not be implemented in Pennsylvania. If they were, the load could be reduced to 495 metric tons/year, a 23% reduction. Future loads without restrictions on detergents may amount to 700 metric tons/year. With restrictions implemented in both states, this could be reduced to 525 metric tons/year, a 25% reduction over the presently projected levels.

The potential phosphorus reductions achieved by restrictions on phosphate detergents and by implementing phosphorus removal technology on these four treatment plants are summarized in Table 9-15.

Non-Point Source Control

Controls on non-point sources of phosphorus are extremely difficult to predict. Non-point source control funds are not available within the grants issued under the provisions of PL92-500. Therefore, non-point source control funds would result directly from state or private (by state mandate) funds (IX.F). In the absence of any definite plans, we will reiterate here a strategy for non-point source control mentioned earlier, namely that emphasis should be placed upon controlling urban and feedlot runoff inputs from Sullivan and Orange Counties, and controls on pastures in Delaware and the other counties should be deemphasized. A 50% reduction in phosphorus loads from feedlots and urban areas in Orange and Sullivan Counties, could reduce the total

Table 9-15 Potential Effect of Various Point Source Phosphorus Control Measures on Total Phosphorus Loading in Upper Basin River (including Pennsylvania portion)[1]

	In Metric Tons/Year	
Control Measure	Present Load	1983 Load
No controls	640	700
Ban on phosphate detergents only	495	525
Phosphorus removal on the four largest plants	(2)	550
Both a ban on phosphate detergents and phosphorus removal from the four largest plants	(2)	437

(1) *Assumes no changes in non-point source phosphorus loading*

(2) This calculation considered only for the future case since implementation would be planned and not a present fact.

load from 640 metric tons/year to 581 metric tons/year. Future loading could be reduced from 700 to 641 metric tons/year. Coupled with the ban on phosphate detergents and phosphorus removal technology in the four largest treatment plants, the total load to the entire upper basin rivers could be reduced from 700 to 378 metric tons/year, a 46% reduction.

Since these controls could be effected in the lower part of the basin, the potential reduction on the total phosphorus reaching the proposed impoundment would likely be much larger than the 46% reduction figure indicated as the nominal decrease in load within the entire upper basin.

IX.A.5 THE EFFECT OF SHAPE AND RESERVOIR OPERATIONS ON THE HYDROLOGY OF TOCKS ISLAND LAKE

All models that have been applied to date, including the Imboden and Dillon models presented in this study, either ignored, or were unable to take into account, the overriding morphological characteristic of the lake; namely, its extreme length relative to its width. Also missing from previous studies are an analysis of the effect of pump storage withdrawals and releases and the advantage selective withdrawal capabilities to meet downstream water quality requirements.

This section presents a discussion of the predicted effects, of selective withdrawal and pumped storage generation upon hydrology of Tock's Island Lake. A scenario is presented employing the concepts of an idealized plug flow model modified to include reservoir operations. The descriptive scenario of the lake's thermal regime is a feasible description of the action of Tocks Island in the mean which can be offered based on available data and a limited study of this aspect (pers. con. Mr. Ray Linsley, P.E., Stanford University, CA).

IX.A.5(a) Reservoir Operations

Selective Withdrawal

The selective withdrawal system is provided to satisfy regulation requirements for water quality control of downstream releases.

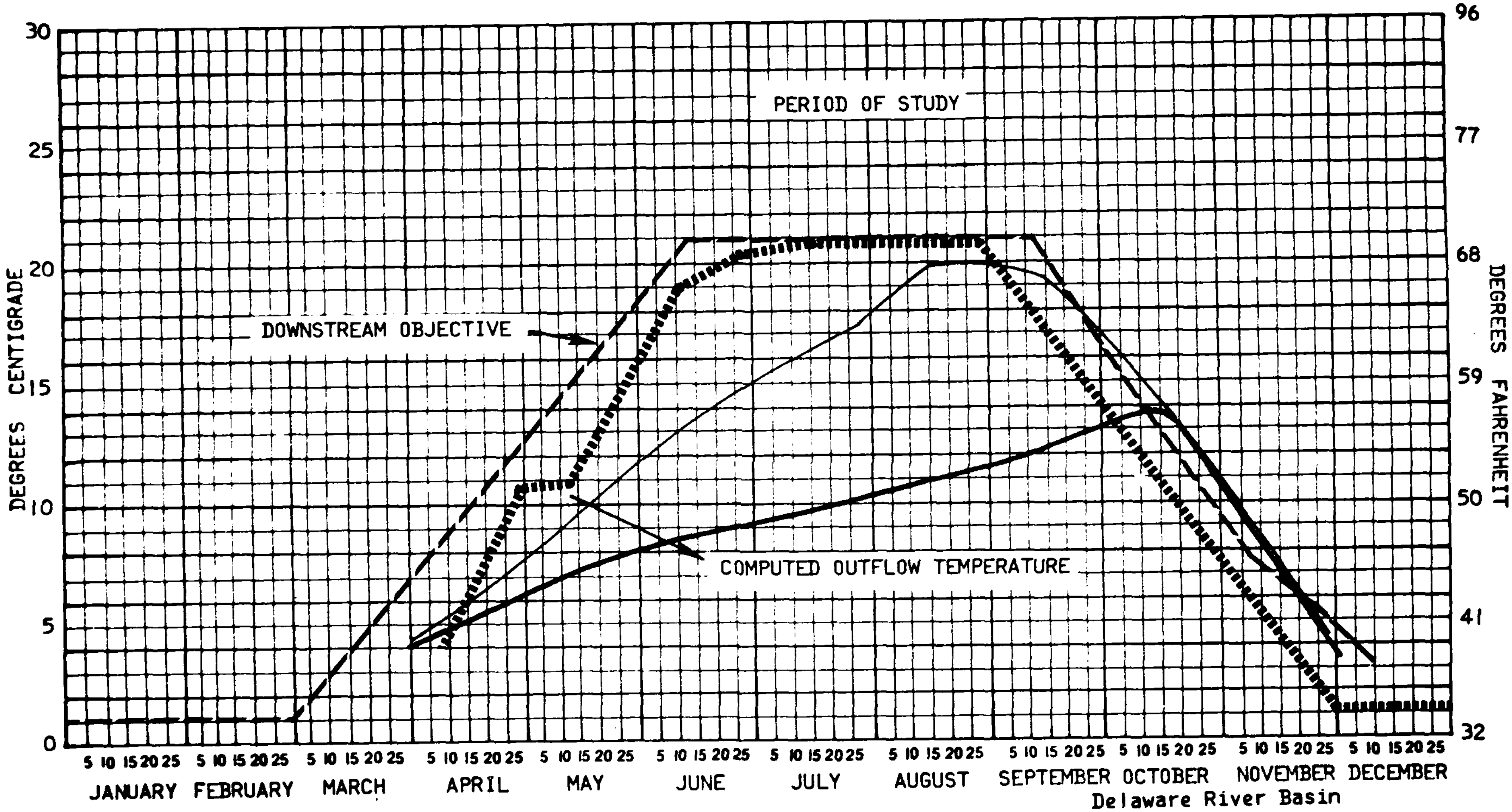
The Corps of Engineers originally designed the selective withdrawal system into the intake tower of the Tocks Island Dam to assure a source of cold water from the hypolimnion mixed with the warmer epilimeotic water (summer conditions) to meet downstream temperature and dissolved oxygen objectives. The facility is presented in Design Memorandum #10. The basic criteria for the temperature of water discharged downstream is that it not be more than $4^{o}C$ away from the temperature of the water in the free flowing river.

To date, no exact temperature objective has been formally established as the target release from the proposed Tocks Island Lake. Therefore, for the purpose of Design Memorandum #10, objective temperatures were established based on the stream temperatures existing below the dam-site. The data were considered "typical" of expected natural conditions and were used in the development of the target outflow temperatures for the study. As stated in Design Memorandum #10, "It is considered that the release of relatively cold water during the summer months would be the most critical temperature objective that would be imposed on the project. Setting the objective temperatures to match the existing conditions for the remainder of the year would minimize the project effects, related to changes in the temperature regime, on the downstream environment."

The proposed dam will be engineered so that water may be withdrawn from a number of levels for downstream discharges or removed to the upper reservoirs to be used for pump storage power generation. The only aspect that need concern us in this discussion is that the intake tower is divided into 12 discrete units between elevations 295 and 410 feet so that water may be withdrawn from any one of the 12 levels in the lake. (See chapter IX.B).

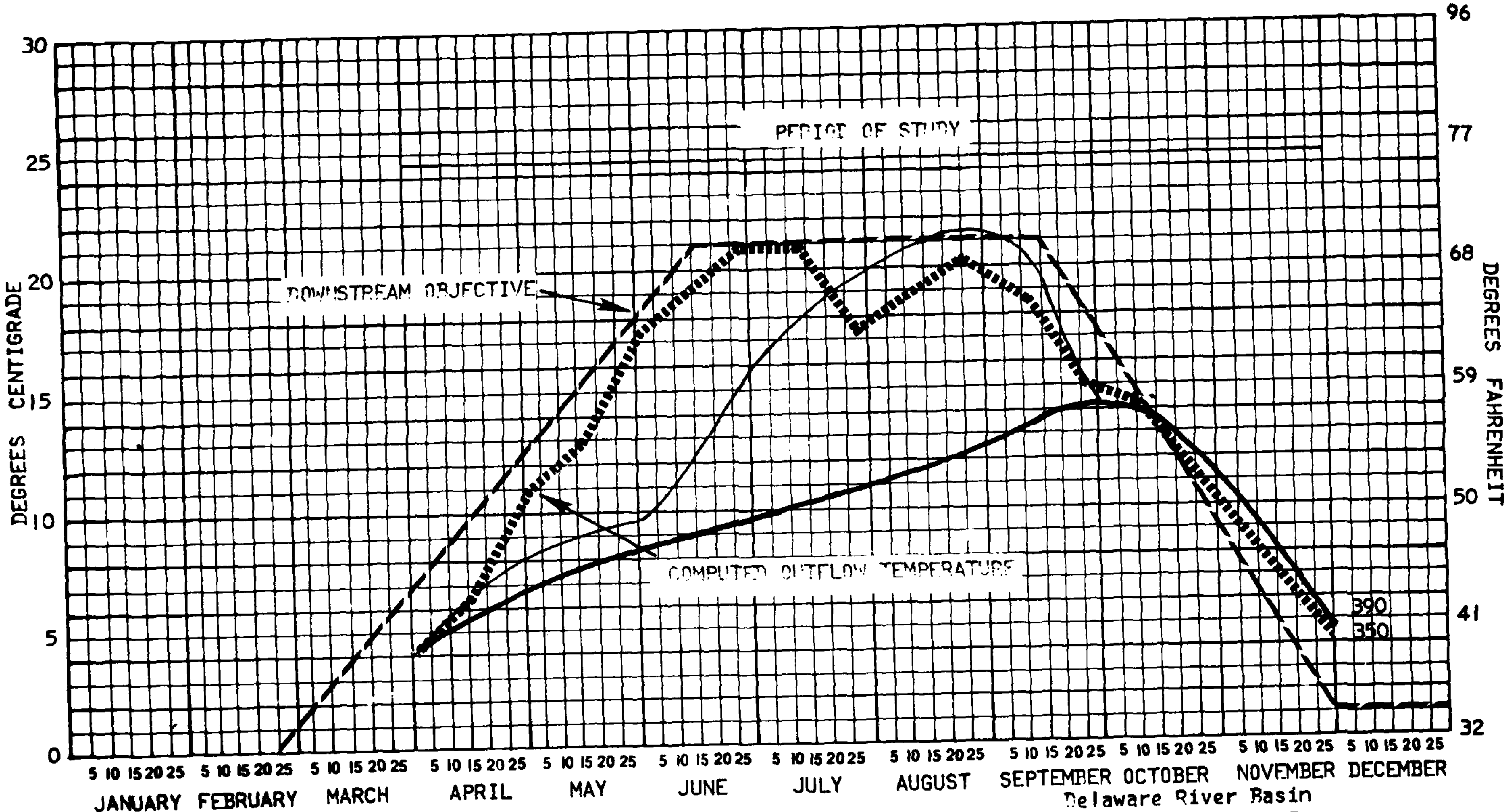
The Corps used the WRE thermal model to predict the build-up of stratification in the springtime and the breakdown of stratification in the fall in Tocks Island Lake for the years 1960, 1962 and 1968. The WRE model required inputs of site characterization data, hydrologic data, meteorological data, hydromechanical data and water temperature data. WRE presented their results in a series of exhibits showing on the same graph the downstream water temperature objective and the computed outflow temperature. In an effort to determine the amount of hypolimnetic water that may be mixed with the warmer epilimnetic water for release downstream, we have superimposed on the three figures developed for conditions in 1960, 1962, and 1968, the variation in temperature with time at 2 depths in the lake, the 350 foot elevation contour and the 390 foot elevation contour. These three figures are shown in Figure 9-4 , 9-5 , and 9-6 for each of the years respectively. The variation in temperature at these depths was taken from the Corps of Engineers Design Memorandum #10 exhibits 3 through 8, showing the build-up and breakdown of stratification for each of the three years as predicted by the WRE thermal stratification model.

From these three figures it is readily apparent that in order to meet the downstream objective for temperature, withdrawals can take place only from the epilimnion at or above the 390 foot elevation contour from 1 April to 1 September in 1960, from 1 April to 1 August in 1962 and from 1 April to 15 July in 1968. Hypolimnetic water, from the 350 foot elevation contour or below, cannot be used without violating the temperature objective until roughly 1 October in each of the years tested. The studies suggest that some hypolimnetic water could be used to lower the discharge temperature for a short period in late August, 1962 and for a one month period from late July to late August, 1968. Since the hypolimnetic water during this period is at a temperature of about 10^{o}C, only a relatively small portion of the discharge water could be hypolimnetic water. Thus, for the most part, these studies indicate that discharge operations will be constrained to using epilimmetic water (according to the WRE model) and, because of the relatively low temperatures predicted, constrained from discharging hypolimnetic water until roughly the 1st of October of each year. Recent studies show that the proposed intake structure may operate efficiently by drawing water from any specific level of the lake only for short periods of time (pers. con. Ray Linsley). Streamlines are formed very quickly from any one intake which can expand to take equal draw from any strata of the lake. Thus, stratification is eliminated also eliminating the effectiveness of the thermoclines.



Delaware River Basin
TOCKS ISLAND LAKE
New Jersey, New York and Pennsylvania
DOWNSTREAM
TEMPERATURES
1960

Appendix A D.M. No. 10 Exhibit 9



Delaware River Basin
TOCKS ISLAND LAKE
New Jersey, New York and Pennsylvania
DOWNSTREAM
TEMPERATURES
1962

Appendix A D.M. No.10 EXHIBIT 10

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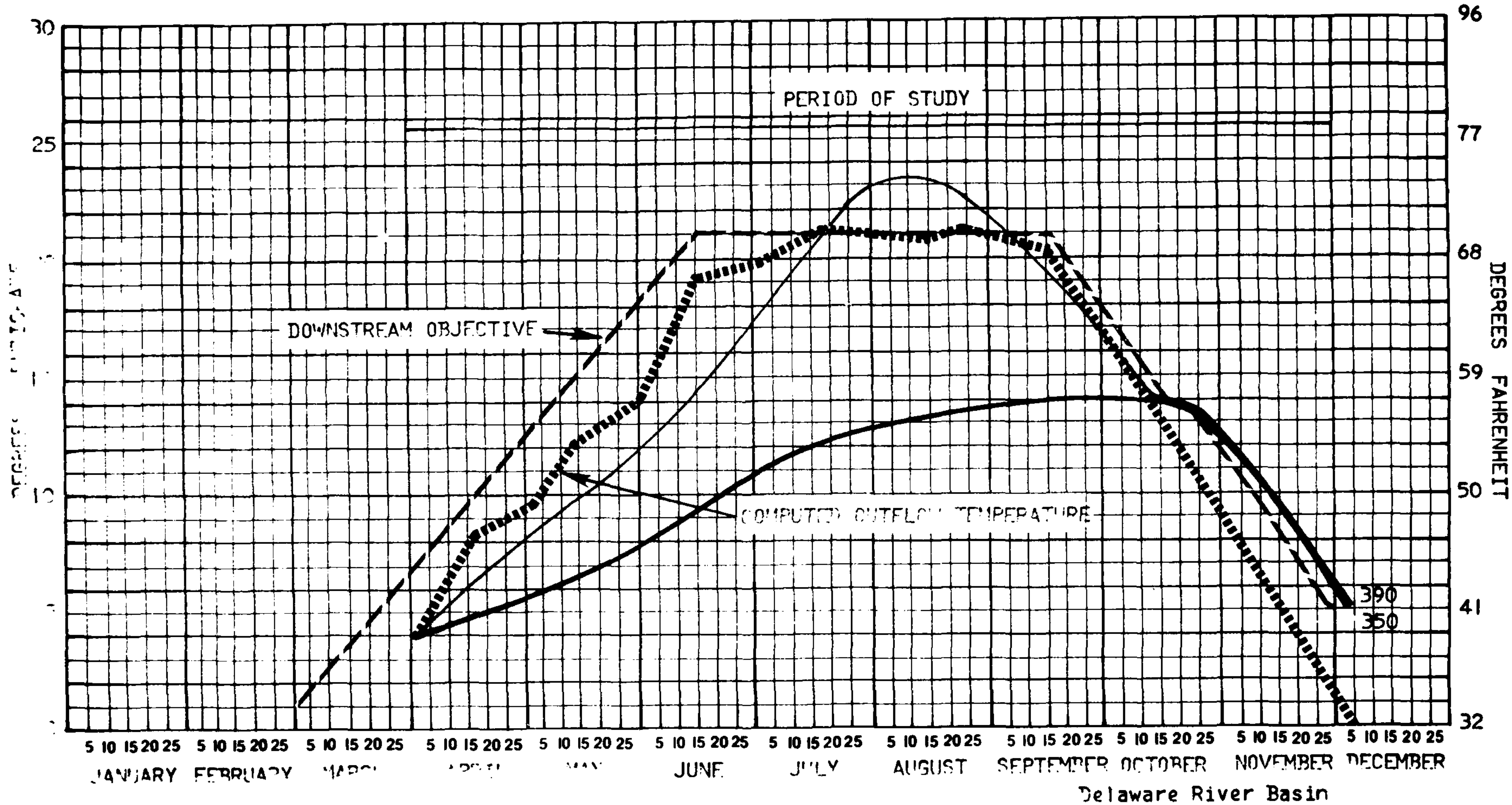

Delaware River Basin
TOCKS ISLAND LAKE
New Jersey, New York and Pennsylvania
DOWNSTREAM
TEMPERATURES
1968

Appendix A D.M. No. 10 Exhibit 11

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A COMPREHENSIVE STUDY OF THE TOCKS ISLAND LAKE PROJECT AND ALTE--ETC(U)

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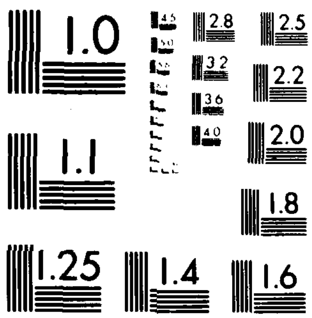

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

IX.A.5(a) Pumped Storage Generation

When the reservoir is in complete operation, water will be removed during the night from the lower impoundment and pumped to the upper reservoir. During times when demand for electricity is high, the water in the upper reservoir will be released to the turbines to provide increased electrical generating capacities. As it leaves the turbines, the flow of water can be in two directions. That which is needed to meet downstream flow requirements will be directed to the river below the dam; any remaining water can be returned to the impoundment. It is not possible at this time to know how the water released from Pumped Storage Generation will be managed; but the extremes of directing all flows downstream or into the impoundment, can herein be considered.

The release of pumped storage water back into the reservoir near the dam probably will tend to destratify the head waters if the flow is substantial enough to cause heavy turbulence, or if the released waters are warmer than the ambient temperature in the strata affected by the release thereby eliminating the thermocline by convection. The actual area of waters open to destratification is subject to numerous variables. However, the destratification will occur in an area affecting the selective withdrawal capabilities planned for the dam. This destratification could be either beneficial or detrimental to the condition of the reservoir and the quality of water discharged. The destratification is detrimental if the epilimnetic waters are cooled below the temperature objective for the discharged water by mixing with hypolimnetic waters. This condition

could persist under the conditions outlined in the last section occuring from 1 April to 15 July in 1968 and 1 April to 1 September in 1960. The destratification can be beneficial if the mixing allows release of the oxygen poor hypolimnetic waters. This can occur at those times of the year when the downstream temperature and dissolved oxygen objectives can be met by such a mix.

IX.A.5.(b) Generalized Hydrologic Effects of Epilimnetic Withdrawal

In general, epilimnetic withdrawal resulting from the maintenance of the downstream temperature objectives will tend to induce stratified flow throughout the length of the impoundment. The tendency will be for the epilimnetic waters over the entire length of the lake to move down the lake faster than the hypolimnetic waters. It is fairly easy to calculate the average daily flow of the epilimnion. Assuming an average epilimnetic depth on 1 July to be about 15 feet, the required rate of discharge through the dam to be 1840 cfs, and the width of the dam to be 0.4 miles (2100 feet). The epilimnion will move about 5,000 feet per day. A 10 foot epilimnion will move about 7,500 feet per day. These velocities come to 3.5 feet per minute and 5.2 feet per minute respectively.

At these velocities, it is conceivable that stratified flow could persist over several miles of any lake particularly if there were no other forces acting to break up the stratification. The very process of one layer of water sliding over another creates a frictional disturbance at

the interface of the two layers causing entrainment of one fluid in another. Once this form of turbulent mixing begins, the stratification will be reduced and more turbulent mixing can occur. Thus, the initiation of the entrainment process would likely cause a rapid decline in stratification. In a lake of this length, even at the slow velocity anticipated for the epilimnetic layer relative to the hypolimnetic layer, substantial entrainment will probably occur from the top of the reservoir on down.

Other mixing processes will also tend to break up the summertime stratification in certain sections of the lake. At the head of the lake, the velocity of water coming in from the river will cause a high degree of turbulent mixing that could extend a few miles down the lake. At constrictions in impoundments where the flow velocity must increase, substantial entrainment will occur. Wind induced mixing may also be a factor of considerable importance.

IX.A.5(c) Plug-Flow Model

As stated in the conclusion of Design Memorandum #10, "it should be emphasized that no appraisal of the hydrodynamics of the impoundment has been made. Such potential problems as density underflows could have a pronounced effect on plans for regulation of outflows." URS has analyzed the hydraulics of Tocks Island Lake for both compliance to temperature objectives and the effect of the lake characteristics upon its trophic state.

The shape and hydraulic characteristics of the lake seem well adapted to the application of a one-dimensional flow model, also termed a "plug-flow" model. In concept, this model would segment the lake into sections defined by hydrologic and temperature regimes, follow the movement of each section down the lake, and predict the trophic state of each section.

The discharge of epilimnetic water only over a major portion of the year may drastically modify the hydrology of the proposed impoundment away from an idealized plug-flow model concept. Such alterations in the hydrologic regime of the impoundment requires consideration of the variations in the tropic state of the lake with time through any given year.

We believe that a major study will be required to elucidate the details of these various mixing processes and their effect upon the

vertical temperature regime and the hydrologic process in the proposed lake. Such a study is far beyond the scope of the present work. The following discussion covers concepts only. Discussion of the hydrological aspects of TILP are useful in making management decisions. Therefore, the following conceptual scenario is presented.

Scenario

By the end of April, the reservoir should be filled to maximum pool with the spring freshet plug. Initially this water will have a temperature of approximately 4°C and will be saturated with dissolved oxygen. This plug can be expected to develop a heavy bloom that may be dominated by diatoms.

By 1 May, water discharged over the dam will be taken partly from the epilimnion. At this time, a modest stratification amounting to less than 1°C per meter probably will have developed forming a combined epi- and metalimnion depth of about 20 feet. Since the epilimnion at this time will be thin, epilimnetic withdrawals required by downstream objectives aforementioned will cause high epilimnetic velocities. The entrainment created by the increased flow rates will cause a mixing of warm with cool waters which may tend to work against the tendencies for the lake waters to stratify due to the effects of solar radiation and rising ambient air temperatures.

At the upper end of the lake, flows in the Delaware are decreasing in velocity and increasing in temperature. The incoming water will tend to flow over the spring freshet plug in the upper lake. Some of the incoming river water may mix with waters in the upper lake to form water of a density comparable to the epilimnion of the lower lake.

By 1 June, stratification in the impoundment will probably be more pronounced. At the dam, water must be drawn from the epilimnion (temperature requirement). At the upper end of the lake, the incoming waters are continuing to decrease in velocity and increase in temperature. This effect will push the cold water wedge of the spring freshet plug further down the reservoir. Again, the incoming river water will mix with the hypolimnetic waters of the upper lake to form water of a density equal to the epilimnion farther down the lake and then tend to flow through the epilimnion. The residence time of this incoming water will be well below the average residence time for the lake as a whole. As calculated earlier, the rate of movement of the epilimnion assuming a 15 foot depth is about 1 mile per day; the resident time of the epilimnetic waters would be about 39 days in mid-summer. This is roughly half that for the lake as a whole.

As this point in the year's scenario, it is difficult to predict whether the epilimnetic waters will suffer a major bloom. The

relatively short residence time tends to work against bloom conditions. However, 39 days is an ample period for bloom conditions to develop. The warm waters would support blooms of blue-green algae and dinoflagilates. Throughout the summertime, the incoming waters are still high in total phosphorus concentration. The entrainment of hypolimnetic waters into the epilimnion tends to add nutrients to the epilimnion thus supporting additional algae growth. Meanwhile, if this model is correct in concept, the hypolimnetic waters consists largely of the spring freshet plug which in all probability suffered an extensive bloom earlier in the year. Thus, the hypolimnion is undergoing a stagnation period of considerable length.

By 1 July, the intensity of the stratification probably has increased. Withdrawals at the dam must still consist largely of epilimnetic water. With increased stratification, two-layered flow is more likely. Since the epilimnion is larger now than in the last month, the epilimnetic flow rate is, on the average, slower. Thus, the entrainment forces working to destratify the lake are reduced. At the head of the lake, incoming water continues to get warmer, pushing the cold hypolimnetic wedge farther down the reservoir.

A potential problem associated with the mixing of incoming waters to form the epilimnion may be discussed at this point. The stratification

model used by the Army Corps of Engineers to predict epilimnetic temperatures at the dam probably did not take into account the entrainment of hypolimnetic water into a relatively fast moving epilimnion. Thus, the epilimnetic waters are likely to be colder by a few degrees than predicted by the model. If this concept is correct, discharges over the dam may have difficulty being warm enough to meet an ambient discharge temperature objective. This is the reverse of the problem anticipated by the Corps of Engineers, but a simple calculation indicates that it is likely to occur. Given roughly equal volumes of epi- and hypolimneon, the residence time of the epilimnetic water is about half the average residence time of the lake, and therefore, the residence time of the hypolimnion must be about twice the average. The water will mix under these conditions in the ratio of about 4 parts epi- to 1 part hypolimnetic. As a general rule, one may expect the epilimnetic temperatures under the conditions assumed here to be up to $4^{o}C$ colder than those predicted in Design Memorandum #10.

By 1 August, stratification has probably reached its maximum intensity, and ambient air temperatures and solar radiation are beginning to decrease. At the dam, it may still be difficult to meet the downstream temperature objectives by withdrawing hypolimnetic water. Epilimnetic withdrawal may induce essentially stratified flow down a large portion of the reservoir. At the upper end of the lake, the incoming water

temperature has reached a maximum and the hypolimnetic cold water wedge has probably been pushed a good deal down the reservoir.

At this point, the hypolimnetic water that remains in the reservoir has been in a state of stagnation for over 120 days. Since it probably received a higher load of organic matter from the spring bloom that took place in the spring freshet plug, dissolved oxygen concentrations in this water are probably well below five milligrams per liter and may approach undetectable levels.

By 1 September, the lake is beginning to undergo the fall overturn. The epilimnion is cooling rapidly and circulating, but the vertical turnover has not penetrated the metalimnion. At the dam, it is still not possible to withdraw hypolimnetic water for discharge downstream without violating the downstream temperature objective. Continued epilimnetic withdrawal together with decreasing stratification may increase the degree of entrainment of hypolimnetic water into the epilimnion. Additional nutrients may be added to the epilimnion by this process thus stimulating even heavier growth of algae in the epilimnion.

At the head of the reservoir, the incoming water is probably slightly colder than the water in the reservoir. Thus, the incoming water

instead of flowing over the water in the reservoir, will probably undercut the existing water and may temporarily form an isolated section of the lake consisting of epilimnetic water from the lower portion of the lake running to a pocket of comparable density water in the upper half.

By 1 October, the lake is probably completely destratified and may be uniform in temperature vertically and horizontally. At the upper end of the lake, the incoming water is still slightly colder than the water in the reservoir and so continues to undercut. The underflow probably will not be sustained for a very long distance down the lake.

At the dam, the temperature at the 350 foot elevation contour is close to the temperature criterion for discharge water, so water from what remains from the hypolimnion can now be discharged. The question is academic by this point, however, since by the middle of October there should be no distinction between the epi- and hypolimnetic layers.

It is conceivable that at this point the nutrient concentration, having been generally increased by the autumn overturn, will stimulate a fall bloom of algae, probably dominated by diatoms.

The validity of the prediction of eutrophic state of Tocks Island Lake from the Imboden and Dillon models tend to be improved by this

conceptual hydrological regime in which discharge from the lake for a good deal of the year consists almost exclusively of epilimnetic water. This is because epilimnetic withdrawal is characteristic of classical lakes, the very lakes that were used to validate the two models. The average residence time of the lake is not affected by the level at which water is taken. What is affected by this hydrologic regime, however, is the stagnation period of the hypolimnion. The Imboden model was adjusted to fit a stagnation period of only 90 days. This anticipated hydrologic regime, however, may create a hypolimnion in the lower end of the lake consisting of residual water from the spring freshet plug some of which has a stagnation period approaching 180 days. Considering the predictions of the Imboden Model, it is entirely likely that this hypolimnetic water will have undetectable dissolved oxygen concentrations at the end of 60 to 90 days, a condition which will persist until the autumn overturn.

It must be emphasized that the foregoing discussion was conceptual in nature. Without extensive research far beyond the scope of the present study, perhaps even a detailed computer-assisted assimilation model, it is not possible to add any detail to this discussion. We believe that the concepts are essentially correct. It is nearly impossible to predict how long turbulent mixing will prevent stratification in the springtime; how far down the reservoir the cold hypolimnetic wedge will be pushed by the end of the summer; the level of

entrainment of hypolimnetic water into the incoming river water; the degree of entrainment of stagnant hypolimnetic water into the flowing epilimnetic water; and finally, the resulting temperature of the epilimnion.

Near the upper end of the reservoir two "narrows" divide the reservoir into longitudinal segments. These segments, or basins, may develop localized regimes which may become special problems, especially since the nutrients will reach these relatively shallow basins first.

Because the reservoir is quite long but with a rather small cross-section, one might suppose that it would tend to function as a river. During flood periods, the water surface in the reservoir will certainly not be horizontal. Flow velocities through the reservoir will be relatively large. If flow is in the epilimnion only, turbulence induced by shear at the thermocline will work to increase mixing. Transverse currents induced at the narrows mentioned above and at Walpack Bend might also encourage mixing and reduce stratification.

IX.A.6 SUMMARY EVALUATIONS

IX.A.6(a) Capabilities of the Models

Each of the models used to predict the trophic condition of the proposed impoundment has assets and shortcomings. They share a common shortcoming in that none is sufficiently detailed to describe the distribution of trophic conditions along a longitudinal axis down the lake. Most models treat the lake as though it were a round, symmetrical depression, the WRE model treats is as though it were a group of well-mixed layers sandwiched together. Imboden's (1974) model is forced to assume that it is a rectangular box with constant depth.

Cahill's arithmetic accounting was far too simple and overlooked too many important processes for it to be used as a guide for management decisions.

The Jack McCormick study was unable to develop a conceptual model, and as a result, their predictions are based upon arbitrary and unsupported decisions.

The ecologic simulation model by Water Resources Engineers (WRE) was highly sophisticated, but it failed to account for the release of phosphorus from the sediments. Also, it may have been overly optimistic in estimating the rate of zooplankton grazing and the response of zooplankton populations to increases in the phytoplankton biomass.

The WAPORA study, which used Brezonik's (1970) criteria developed in a study of small lakes and ponds in Florida, arrived at conclusions based upon criteria that had not been validated for limnological conditions expected to occur in northeastern Pennsylvania.

The study by Fuhs and Allen (1974) utilized the models developed by Vollenwider (1968) and Imboden (1974). The morphology, hydraulic and phosphorus loading functions of the proposed lake are compared with the same functions in other lakes in the same area or at similar latitude presenting a more convincing prediction. However, the model cannot properly take into account Tocks Island Lake's irregular shape. The application of this model eliminates from consideration any description of changes in the trophic states along the longitudinal axis. It describes

instead an imaginary condition that might be called the average trophic state of the lake.

Imboden's criteria for the initiation of an eutrophic condition were more severe than water resources managers in the Delaware River basin would be willing to accept. In this study, Imboden's model was revised so that the criteria for the initiation of eutrophy were made less stringent. Even with the revised criteria, the model predicts the Tocks Island Lake to be eutrophic. A more precise statement of this prediction is that the hypolimnion of Tocks Island Lake will, on the average, suffer a reduction in dissolved oxygen concentration of greater than 5 mg/ℓ over a 90-day period of stagnation.

The Dillon (1975) model, combined with the work of Dillon and Rigler (1974) and Carlson (1974), was used in this study to predict the average summertime Secchi Disk readings of the lake The Dillon model also takes a holistic view of the lake, and thus, cannot be used to effectively describe changes in the trophic state of the lake along the longitudinal axis. The application of reasonable values for flushing rate, phosphorus retention coefficient, and phosphorus loading rate to the Dillon model indicates a range of summertime Secchi Disk readings of between .6 and 2.1 meters. The most likely range, however, is

0.6 to 1.2 meters. The application of the Dillon model requires a number of arithmetic transformations, each of which carries with it a given uncertainty. The uncertainty in the final result, in this case the range of possible Secchi Disk readings, may represent a sizeable fraction of the predicted values. As indicated in the discussion of the Dillon model, if corrections are made to take into account the systematic errors between the predicted and observed phosphorus concentrations the corrections would favor even lower Secchi Disk readings. Thus, we feel that the model gives a conservative prediction favoring a mesotrophic rather than a eutrophic state. With correction taken into account, the Dillon model predicts a Secchi Disk transparency of 0.2 to 1.0 meters in the surface waters of the lake on the average during the summertime.

IX.A.6(b) Overall Assessment

It is our opinion from the analysis of studies performed to date on the proposed Tocks Island Lake, from the adjustments to the Imboden model made as a part of this study, and from the application of the Dillon model with transformations to obtain the summertime Secchi Disk readings as also developed in this study, that the proposed lake may be classified eutrophic.

Since the predictions presented herein of the appearance and trophic state of the lake are subject to imprecise value judgements by scientists, it may be more precise to state this another way. We believe that a concensus of opinion among limnologists, making independent rational scientific judgements about the lake once it is constructed, would be that it is eutrophic.

The state-of-the-art, at the present time, does not permit a quantitative evaluation of variations in the trophic state of the lake along the longitudinal axis. It is entirely likely that the appearance of the lake at any point will vary widely with seasons, but at the present time, we can only speculate on conceptual models for this variation. Once such concept has been discussed in Section IX.A.5.

Because the soil of the flood plain, and the normal vegetation and debris present along this reach of the Delaware contain phosphorus that should be immediately available to the water column to support algae growth once the impoundment is flooded, the appearance of eutrophy will be worse for the first few years than it will later on. There is no way at present to quantify this in terms of degree of eutrophy or decreases in the transparency of the water column in the summertime.

The valley of the Flatbrook will, once the impoundment is created, probably be a backwater. Since the volume of water impounded within the Flatbrook valley has not been calculated, it is not possible to determine the flushing rate of that impoundment. The general shape of the branch and the size of the impoundment relative to the present flow of the Flatbrook river, however, suggests that advective flushing will not be a major process. The most powerful flushing process for this backwater would be changes in the elevation of the lake. Since the daily fluctuations are not expected to be large, this flushing action will probably not be effective in replacing the water in the Flatbrook branch.

If these predictions are true, the Flatbrook will have the appearance of greater eutrophy than the rest of the lake. Secchi Disk readings would probably be lower than average, amounting to only a fraction of a meter. Decreases in transparency with increasing Chlorophyll a concentrations become progressively smaller and at Secchi Disk readings of less than 1 meter, very large increases in Chlorophyll a concentrations are required to noticably decrease the Secchi Disk reading.

Dissolved oxygen concentrations in the hypolimnion of the Flatbrook will probably be reduced by far more than 5 mg/ℓ and may be below 5 mg/ℓ for much of the summer.

IX.A.6(c) Effect of Best Practical and Economically Feasible Waste Treatment Technology

Since it is not known at the present time what the best practical and economically feasible technology will be in terms of the amounts of total phosphorus removed from input waters to the Delaware River system, it is not possible to give a definitive estimate of the impact of implementing such technology on the trophic state of Tocks Island Lake. As was indicated earlier in this section, however, the implementation of a ban on phosphorus in detergents sold and used in New York and Pennsylvania would reduce the annual load of total phosphorus to waters of the upper basin (New York and Pennsylvania together) by about 25 percent. The implementation of 95 percent phosphorus removal (PL 92-500) on the four largest wastewater treatment plants in the upper basin -- Liberty, Fallsburg-Woodborne, Monticello, and Port Jervis -- would reduce the annual total phosphorus load from all sources by 13 percent. Combining the ban on phosphate detergents and the phosphorus removal technology in the four largest treatment plants would reduce the annual load of total phosphorus by some 38 percent. Combining these two controls with a modest control on urban and feedlot runoffs in Sullivan and Orange Counties New York, would reduce the annual total phosphorus load from all sources by 46 percent.

However, the basin-wide reduction in annual total phosphorus loading does not tell the entire story. Since rivers tend to be self-cleansing, and the Pepacton and Cannonsville Reservoirs probably intercept large quantities of nutrients generated on the East Branch and West Branch in Delaware County, the total phosphorus load generated in Sullivan and Orange Counties probably contributes more to the observed total phosphorus concentration at Montague than does the total phosphorus load from areas farther up the basin. Thus, the implementation of controls on point and non-point sources in Sullivan and Orange Counties, New York would probably effect a much larger reduction in total phosphorus load to the impoundment than is indicated by the figures showing basin-wide average reductions.

Presuming that controls on point and non-point sources, as suggested, were implemented, the effect on annual total phosphorus loads to the impoundment would be to decrease the load by at least 50 percent. According to the Dillon model, the predicted Secchi Disk reading on the lake during the summertime would increase from the presently predicted range of 0.6 to 1.2 meters to 1.2 to 2.2 meters. Since the decrease in total phosphorus load to the lake is likely to be even greater, the predicted range of Secchi Disk readings is likely to be located at a higher level yet. Since the Secchi Disk reading is a hyperbolic function of the Chlorophyll-a concentration, further decreases in the annual loading of total phosphorus below the level of 3 grams per square meter per year, have a profound effect on the Secchi Disk reading.

IX.A.6.(d) Estimating Changes in the Trophic State of Tocks Island Lake With Various Pollution Control Strategies

Changes in the phosphorus load to the basin rivers will ultimately lead to changes in the phosphorus load to Tocks Island Lake. The object of this section is to relate changes in the phosphorus loading under various pollution control strategies to changes in the appearance of Tocks Island Lake.

Two different types of estimates are made:

1. The first assumes that fractional reductions in the basin wide total phosphorus loading to rivers will be passed on down the basin to Tocks Island Lake, causing an equal fractional reduction in the phosphorus loading rate.

2. The second approach assumes that reservoir in the New York portion of the drainage basin effects total phosphorus loads of waters entering Tocks Island Lake.

In estimate #1, the numerical analysis begins with a basin-wide phosphorus load of 700 metric tons/year in the year 1985. The phosphorus loading rate is set at a high of 6.0 g/m^2/year (Fuhs' and Allens' value calculated in 1973) and a low of 3.1 g/m^2/year (WAPORA's value calculated in 1969). The projected decrease in total phosphorus load due to each presumed treatment strategy is subtracted from the base loading value of 700 MT/year. The fractional decrease in this value is applied to the phosphorus loading rates as though the fractional decrease in loads would cause an equal fractional decrease in loading rates. The new

loading rates are then used in both the Dillon and revised Imboden models to calculate the midsummer Secchi Disk reading and the trophic state of Tocks Island Lake.

In estimate #2, an attempt was made to achieve a closer degree of realism by assuming that existing reservoirs in the upper basin effect a reduction in total phosphorus loads to the mainstem of the river at Port Jervis. These include the Cannonsville, Pepacton, and the Neversink reservoirs (see Chapter VI).

By trying to approximate this effect, we hope to simulate the effect of control measures upon nutrient sources closer to TILP. As such, drainage from the upper basin reservoirs is treated as point sources to the mainstem.

It is assumed that the East Branch and West Branch point sources drain into the Cannonsville and Pepacton Reservoirs. Further it is assumed that the entire point source load from the Pennsylvania portion is reduced a comparable amount. Non-point sources in Delaware, Broome and Greene Counties, New York are also treated in this manner. These assumptions are summarized below:

	Original	Reduced 50%
Point Sources	kg/year	kg/year
West Branch	26,426	13,213
East Branch	10,810	5,405
Pennsylvania	90,000	45,000
Non-Point Sources		
Delaware County	87,329	43,665
Greene County	1,620	8,310
Broome County	9,549	4,775
Pennsylvania	82,000	41,000
GRAND TOTAL	307,734	153,867

It should be emphasized that this approach does not pretend to be fully realistic in describing phosphorus dynamics in the basin. It attempts to account for the fact that existing reservoirs remove about 50% of the phosphorus from waters high in the New York Portion of the basin and in most or all of the Pennsylvania portion and, therefore, pollution control strategies effected lower down in the basin will have a more significant effect upon the proposed lake. It presumes that once waters enter the mainstem of the Delaware, processes acting to remove phosphorus further from the water act equally on all the phosphorus, regardless of source.

The phosphorus load to the mainstem was reduced for the purposes of this calculation 154 metric tons/year, (as per the % flow contribution from the affected portions of the basin). Thus, the 700 MT/year. This load was presumed to create the same phosphorus loading rate of a high of and a low of 6.0, 3.1 g/m^2/year to the proposed lake. Reductions in phosphorus load due to various control strategies are subtracted from this figure and the percentage decrease applied to these loading rates to compute new loading rates. The new figures are then applied as in estimate #1 to both the Dillon and revised Imboden models to estimate the characteristics of the lake.

Results

The control strategies are as follows:

A. Assumptions and conditions as expressed in IX.A.4.

B. Complete ban on detergents for New York State.

C. 95% phosphate removal from the four largest treatment plants only. These are Liberty, Fallsburgh-Woodborne, Port Jervis, and Monticello (see Table 9-12).

D. Combination of a phosphate ban and 95% removal from the four largest treatment plants.

E. Combination of a phosphate ban, 95% removal from the four largest treatment plants, and a 50% reduction from urban areas and feedlot in Orange and Sullivan Counties in New York.

Results of these two types of estimates for four presumed treatment strategies are shown in Table 9-15.

Table 9-15

PREDICTION OF TROPHIC LEVELS IN TOCKS ISLAND LAKE UNDER VARIOUS ALTERNATIVE CONTROL STRATEGIES

1985 Conditions	Assuming NO Phosphorus Removal in Reservoirs									Assuming 50% Removal in Selected Reservoirs								
	Nominal Phosphorus Load	Basin-wide Phosphorus Decrease	Phosphorus Loading Factor g/m^2/year		Midsummer Secchi Disk (Dillon)		Trophic State (Imboden, Revised)		Nominal Phosphorus Load	Basin-wide Phosphorus Decrease	Phosphorus Loading Factor g/m^2/year		Midsummer Secchi Disk (Dillon)		Trophic State (Imboden, Revised)	
			High	Low	Low	High	High	Low			High	Low	Low	High	High	Low
Description of Control Measure	MT/year	%	(1)	(2)	m	m	(4)		MT/year	%	(1)	(2)	m	m	(4)	
1. No new controls beyond those present in 1973.	700	0	6.0	3.1	.5	1.1	E	E	546	0	6.0	3.1	.5	1.1	E	E
2. Ban on phosphate detergents only.	525	25	4.5	2.3	.8	1.5	E	E	371	32	4.1	2.1	.9	1.8	E	E
3. Phosphorus removal from the four largest treatment plants only.	553	21	4.7	2.4	.7	1.5	E	E	399	27	4.4	2.3	.8	1.5	E	E
4. Basin-wide ban on phosphate detergents and phosphorus removal from the four largest treatment plants both.	434	38	3.7	1.9	1.0	1.9	E	E	280	49	3.1	1.6	1.2	2.2	E	M
5. #4 plus 50% reduction from urban areas and feedlots in Orange and Sullivan Counties, N.Y.	371	47	3.2	1.7	1.2	2.1	E	M	217	60	2.4	1.2	1.5	2.8	E	M

(1) Based upon Fuhs and Allen's (1975) work.

(2) Based upon WAPRA's (1971) work.

(3) For simplicity, assume a retention coefficient (R) of 0.3 and a flushing coefficient (p) of 4.5 $year^{-1}$.

(4) E - eutrophic, M - mesotrophic, 0 - oligotrophic.

(5) Assumes 5 mg/ oxygen decrease in 90 days of stagnation as the eutrophication criteria.

The results of both estimates suggest that taken together a basin-wide ban on phosphate detergents, phosphorus removal from the four largest treatment plants and a 50% reduction in pollutant loads from urban areas and feedlots in Orange and Sullivan Counties, New York can effect the transformation of the proposed lake from eutrophic to mesotrophic, increase the midsummer Secchi Disk reading to a range of 1.2 to 2.1 meters assuming no phosphorus removal by reservoirs and 1.5 to 2.8 meters assuming 50% removal by reservoirs.

The two values of 6.0 and 3.1 g/m^2/year for the phosphorus loading rate to the proposed lake were both employed as base figures in order to add perspective and range to the argument. We believe that 3.1 g/m^2/year is too low, and tend to agree with Fuhs and Allen's (1975) figure of 6.0 because of the sampling, storage and analytical procedures and by Fuhs and Allen were felt to be of very high quality.

The shape and expected hydrology of the proposed lake will probably alter the flow regime so that the hydrology will not be exactly comparable to that of lakes used to verify the trophic state models. It is not possible to say with any certainty how this will affect the changes in the characteristics of the lake, with implementation of various pollution control strategies. The problem is that epilimnetic withdrawal, while characteristic of classic lakes, may cause unusual and unstudied hydrologic effects in very elongated reservoirs as Tocks Island.

IX.A.6(e) Impact of Eutrophy on Beneficial Uses

IX.A.6(e)(1) Water Supply

If the predictions of the Dillon model with the concepts of a plugflow model superimposed, the algae concentration in water released from the "spring freshet" plug will be fairly high. This will probably be the only plug wherein the concentrations will be high in the lower (toward the dam) part of the impoundment.

Hull (1974) found in a survey of operators of municipal water-treatment plants that the operators were confident that additional concentrations of algae in the incoming water could be handled with existing equipment without great difficulty. Thus, the municipalities receiving water from the spring freshet plug shouldn't have any trouble treating the water for algae removal. The natural processes of the river reach downstream of the dam will also be fairly effective in removing algae from the water. The observation in the Cannonsville Reservoir discharge is that even large concentrations of algae released to the New York City water system at several times during the summer are significantly reduced after traveling for a few miles in the free flowing river. Thus, the combination of present water treatment capabilities and the distance that the water will have to travel from the dam to the intake of the first water treatment plant (32 miles) will limit the impact of high algae concentrations in the "spring freshet" plug upon the use of the impoundment for water supply.

IX.A.6(e)(2) Flood Control

Eutrophication in the Tocks Island Lake should have no effect whatsoever upon the use of the impoundment as a flood control reservoir. Eutrophy will, however, shorten the effective lifetime of the reservoir by increasing the filling rate by adding additional loads of organic material to the substrate. We are unable to predict the magnitude of this effect.

IX.A.6(e)(3) Power Generation

Eutrophy will have no effect whatsoever upon the capability for power generation.

IX.A.6(e)(4) Recreation

Eutrophication, to the extent predicted for Tocks Island Lake, will have a detrimental effect upon the use of the lake for recreational purposes. The upper third of the lake will probably, with the present phosphorus loading conditions, experience high concentrations of algae from early spring to late autumn. If this is the case, Secchi Disk readings will probably be of the order of .5 to 1.2 meters, a condition which most swimmers and boaters would call "murky". We do not believe there is any reason to suspect a potential health hazard from this condition since eutrophy does not suggest a simultaneous occurrence of pathogenic organisms. According to the Medical Society of New Jersey, bluegreen algae are mildly toxic to the human intestinal system if swallowed in large

quantities. We believe that it would be virtually impossible for a swimmer to swallow enough water to cause any, even the mildest, ill effects.

Alternatively, eutrophication could manifest itself in dense growths of macrophytes along the shallow portions of the lake (Chapter IX.B). The macrophytes would shade the water and prevent blooms of suspended algae over the portion inhabited by macrophytes. These plants are quite as effective as algae in removing phosphorus from the water. Excessive growth of macrophytes could restrict both boating and swimming but would provide both abundant food and shelter for fish.

Dissolved oxygen concentrations in the hypolimnetic waters of the upper reach of the lake may be reduced. However, the extent of the reduction should not affect the fish population of that reach, since the reach is relatively shallow and the reaeration coefficients should be larger than for the rest of the lake. Low dissolved oxygen concentrations in the hypolimnetic water will occur in the late springtime and summertime plugs as they move farther down the impoundment.

High phosphorus concentrations may lead to high concentrations of periphyton algae; that is, algae attached to solid surfaces. This aspect has not been considered previously, but is commonly observed

in freshwater streams receiving high nutrient concentrations. It is possible that sandy beaches may be colonized by periphyton algae species, thereby becoming slick and unsightly.

We see no reason to believe that the water around the recreational beaches will have an unesthetic odor.

In summary, some swimmers and boaters will find the conditions of the upper lake uninviting. The water will probably be turbid, the beaches may be covered with periphyton algae and the shallow areas may be colonized with rooted microphytes. Other swimmers and boaters may find the conditions acceptable because few other choices are available. From a recreational viewpoint, fishermen may find the lake inviting because of the warm water sport fishery (Chapter IX.C). Speedboat enthusiasts will more than likely gravitate to the middle and lower stretches of the impoundment. Canoeists and small boat fishermen will occupy the upstream reaches. Swimmers may find the periphyton algae growing on the beaches to be a minor nuisance, but we believe that the condition will be no different from the conditions experienced by swimmers at any lake in the three-state area.

CHAPTER IX.A BIBLIOGRAPHY

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IX.B. RESERVOIR OPERATIONS

The Tocks Island Lake Reservoir will be operated by the Army Corps of Engineers under the guidance of the DRBC. This section will consider those reservoir operations affecting downstream discharges and reservoir fluctuations.

IX.B.1 DOWNSTREAM RELEASES

Downstream release schedules will depend upon the inflow to the reservoir and the downstream demand. Downstream flow will be measured at Trenton, New Jersey on the basis of a minimum average daily flow. A minimum average daily flow of 2,790 cfs will be released from Tocks Island Dam in order that a flow of 3,000 cfs be maintained at Trenton. Instantaneous rate of flow is the amount of water discharged at any particular time by the reservoir. Instantaneous flows will range from a minimum of 1,800 cfs to a maximum of 3,900 cfs under normal conditions.

Under normal operating conditions, waters passing through the selective withdrawl facilities will pass through the conventional hydropower turbines. Waters will also pass through the selective

withdrawl facilities in entering the Pumped Storage Generation (PSG), Kittitinny Mountain Project.

When the planned outflow is greater than that needed for power generation (i.e., flood conditions), it will be released through the spillway "tainter" gates. These 40-foot high gates will also enable water to be selectively withdrawn from different depths within the reservoir, thereby allowing selection of temperature, dissolved oxygen and, if necessary, nutrient loads.

The selective withdrawl facilities were instituted within the TILP design to maintain downstream dissolved oxygen and temperature levels as acceptible for the resident and anadromous fish of the area. Army Corps of Engineers Design Memorandum #10 describes the outlet works as consisting of "two 24-foot diameter tunnels, each having an intake tower divided into two 10.5-foot by 24-foot passageways. Each passageway has a selective withdrawal system consisting of six overlapping bulkheads 15.0, feet wide by 20.0 feet high, on separate tracks between elevations 295 and 410, on the upstream face of the intake tower.

Planning standards call for a minimum dissolved oxygen release of 5mg/1 and a maximum temperature variation of 4°C from ambient seasonal river temperature. This temperature objective is related to the expected maximum, minimum and mean temperature of the free flowing

river recorded at east Stroudsburg, PA.

Several mathematical models have been developed in recent years in an attempt to describe the seasonal variations of thermal conditions in an impoundment. The Corps of Engineers used for their study of the effects of the proposed selective withdrawl structure for Tocks Island Lake, a model developed by Water Resources and Engineers. The model, which is based on a form of the one dimensional heat balance equation, analyzes the exchanges of heat energy for a deep impoundment and it computes the thermal stratification imposed on the impoundment as a result of the temperal variation in inflows, outflows, heat transfer at the air-water interface and internal heat transfer processes such as vertical advection and defusion. The expected typical release temperatures for the downstream reaches below the Tocks Island Lake Project is shown in Figure 9- 7 . The temperature objective is related to specific years in Figure 9- 4 , 9- 5 , and 9- 6 of Section IX.A.5.

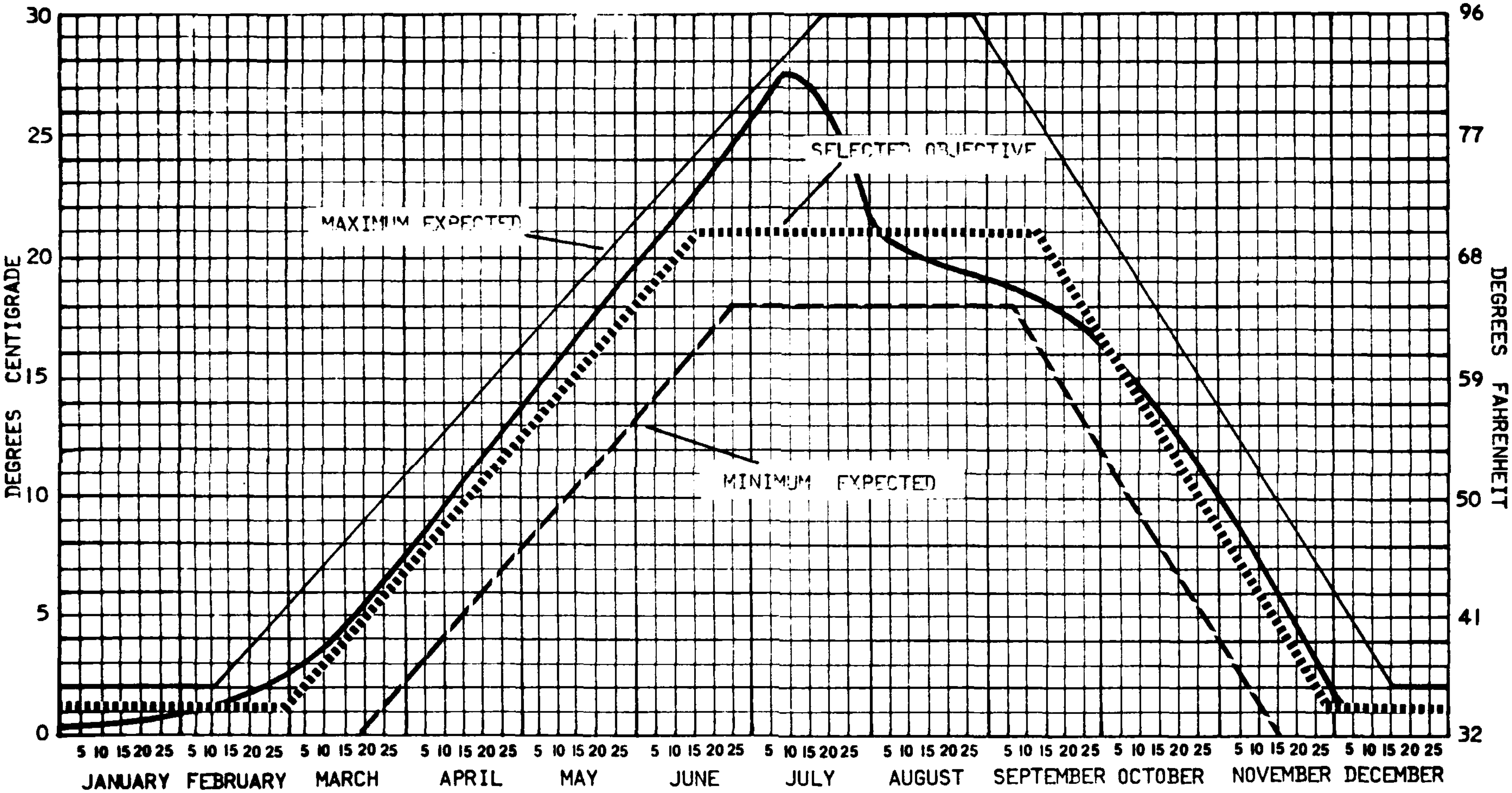
The efficiency of the selective withdrawl facilities have been discussed in IX.A.5. As stated, the facilities only serve the intended purpose when the lake is stratified and a termocline exists. In the early to late summer (the period in which the facilities serve to effectively regulate DO and temperature levels below the dam) the lower lake may become destratified due to PSG or streamlines encompassing more vertical area than the intended strata to be withdrawn.

It should be noted that the "state of the art" of selective withdrawl mechanisms is advancing due to the widespread use of the facility in reservoirs around the country.

IX.B.1(a) River Flows

The released water will affect salinity variations, dissolved oxygen, and degree of dilution of the downstream reaches. The salinity gradient within the Delaware Bay estuary depends upon the rate of flow from the river. Therefore, variations in river flow will cause some variation within the salinity gradient. The effect of salinity gradient upon the aquatic biota is considered in Chapter IX.H.

Increased flow rates within the mainstream will result in higher dissolved oxygen concentrations through natural turbulence (an increase in the aeration). The increased riverflow may also act to dilute the pollutant loads entering the river from the Lehigh and other sources. To date, there has been a great deal of controversy around the dissolved oxygen "sink" in the Philadelphia-Camden area. Low summer flows allow a long residence time of these pollutants within the river area before entering the Delaware Bay estuary. Increased flows could very well push the pollutant loads into the Bay without undergoing the biodegradation now experienced between Philadelphia and Wilmington. Thus, oxygen demanding wastes could affect the DO levels of the upper Delaware Bay.



NOTE: MAXIMUM AND MINIMUM EXPECTED TEMPERATURES BASED ON RECORDED DATA FOR STATION NEAR EAST STROUDSBURG, PA.

Delaware River Basin
TOCKS ISLAND LAKE
New Jersey, New York and Pennsylvania
RELEASE TEMPERATURE OBJECTIVE
1972 - 1973
AT PORT JERVIS

A number of models have been created under the auspices of the Army Corps of Engineers schedules. These models deal with both steady and transient releases having release rates of 3,000 cfs to 24,000 cfs. The results of the models indicated that increased flow from the Tocks Island Lake would increase the dissolved oxygen concentrations from Trenton to Philadelphia and then decrease the dissolved oxygen concentrations from Philadelphia to the Delaware Bay. Steady state flows of 6,000, 9,000, and 12,000 cfs resulted in dissolved oxygen variations of respectively 1, 3, and 4 mg/l. The river reaches below Philadelphia showed dissolved oxygen decreases of 1 mg/l.

"Pulse flow augmentation" and "rampdown releases" are two forms of transient release. Pulse flow augmentation is characterized by high initial flows for an intensive period followed by a rapid decrease in flow. Rampdown releases are characterized by prolonged high initial flows and a longer period of tapering towards low flow levels. The pulse flow augmentation of 24,000 cfs over a 15-day period and decreasing to 2,400 cfs over the next 35 days produced fairly significant short-term effects. The model indicated dissolved oxygen increases of 3.0 mg/l occurring between Trenton and Philadelphia, and a depression of as much as 7.0 mg/l at Wilmington. The estuary is expected to return to ambient dissolved oxygen levels within a short time after the pulse.

Rampdown releases of 10,000 cfs which decrease at a uniform rate over a 355-day period to 3,000 cfs produced a maximum dissolved oxygen increase of 2.0 mg/l above Philadelphia. The river stretch between Philadelphia and Chester showed ambient dissolved oxygen levels.

Nitrogen supersaturation damage to fish as a result of spillway design has been experienced in rivers having anadromous fish runs such as the Columbia River in Oregon. A 376-foot wide chute will extend approximately 578 feet downstream from the toe of the discharge weir of the Tocks Island Dam to the stilling basin. The stilling basin is designed to extend an additional 204 feet from the end of the chute to the end sill, (Design Memo #10). As stated inIX.C.2, the pressure acting to dissolve the nitrogen will be considerably reduced by the planned stilling basin. In addition, since the Tocks Island Dam is a solitary mainstem dam, long-term supersaturation created by a series of impoundments on the mainstem of a river will be eliminated. As a result, it is highly unlikely that nitrogen gas bubble disease will affect the resident or anadromous fish populations of the Delaware River.

IX.B.2 WATER LEVEL FLUCTUATIONS

The water level within both the reservoir and the downstream reaches will fluctuate daily and seasonally. These fluctuations

will result from power generation, flood control measures, and downstream flow demands. Normal operation of the PSG will result in daily level changes averaging seven to nine inches with a maximum of 16 inches. Effects upon the biota from PSG are presented in IX.E. Drawdown for flood control and other intended purposes will produce much higher seasonal variations in reservoir levels. These levels and their effect upon recreation are presented in XI.A.3.

Drawdown will affect the aquatic biota and vegetation. Rooted aquatic and semi-aquatic plants are expected to become established around the shallow submerged area of Tocks Island Lake. This vegetation will become established in the photic zone (the zone in which light penetration through the water column is sufficient to allow photosynthesis). In general, the photic zone represents shallow depths in very turbid water and will extend deeper in clear water. Reduced light penetration due to eutrophic conditions expected in Tocks Island Lake (See Chapter IX.A) will in all probability limit the lower reaches of the photic growth zone to a maximum of 6 to 10 feet.

Vegetation is expected to be densest on the shoreline in sheltered areas with gentle slopes. Cattails, rushes and other similar regional plants are expected to colonize the area existing between

the 400 to 409 foot elevations. Willows are expected to become established and be dominant at the maximum normal water level (410); other semi-aquatic species will also be associated.

Little or no vegetation is expected in areas with strong wind or wave action, very steep slopes or rocky shores. Semi-aquatic vegetation (macrophytes) may become established on artificially created sandy beaches. However, heavy recreational use is expected to keep this growth from becoming a problem.

Daily fluctuations reaching a maximum of 16 inches from PSG will limit the type of vegetation that can become established around the Tocks Island Lake shoreline. However, this fluctuation will not inhibit the growth of aquatic and semi-aquatic vegetation.

Since the photic zone is expected to extend a maximum verticle distance of 10 feet, aquatic vegetation below the 400 foot elevation will be nearly non-existent (Considering a 410 foot pool.) The substrate between 390 to 400 foot elevation will be exposed late in the growing season due to drawdown so that only fast growing semi-aquatic and terrestrial annuals will become established on the exposed soils. This will occur if the water level remains constant for several weeks at drawdown levels and the weather remains fairly warm. The chances of colonization by annual vegetation on the exposed soil

is increased if rain is abundant after drawdown followed by several weeks of warm weather. Any resulting vegetative cover is expected to be sparse, but may be evenly distributed where the substrate consists of fertile, silty soils. Therefore, stabilization of the fine particulate, silty soils by vegetation may not be substantial to retain the new soils against rain and wind erosion. Semi-aquatics such as rushes and cattails will survive winter drawdown by becoming dorment (emergent aquatics like cattails), as seeds, or by surviving periodic drought conditions (willows).

Mosquito populations induced by the reservoir will be minimal, particularly if there are frequent fluctuations in the water level. Stagnant pools, which are prime breeding grounds, will be subject to inundation with water level rises exposing the eggs and larvae to predation by fish. A mosquito needs approximately 30 days to complete its metamorphic cycle, so reservoir fluctuations of greater incidence will minimize any vector problem considerably. On the other hand, if the reservoir water level remains relatively constant, there will be occasional outbreaks of mosquito populations, and contingency plans must be available to deal with the problem.

Fluctuating water levels due to reservoir drawdown practices may impair the spawning activities of game and trash fish. As stated in IX.C, drawdown may be a technique to manage the trash fish

population by exposing fish nests. The total range of species affected by drawdown is not known; however, some of the predators which spawn in shallow waters may be affected. These include pickerel, Northern pike, and muskellunge. As stated in chapter XI.H, "In summary, drawdown could affect the eggs of numerous fish species within the reservoir. Even though the time of the exposure may not be sufficient to kill an egg, it does make the egg less resistant to extreme fluctuation in temperature or dissolved oxygen. It has been suggested that simulation studies more closely approximating Tocks Island drawdown may be used to decrease trash fish populations while promoting game fish dominance."

IX.C. FISH AND WILDLIFE

IX.C.1 RESERVOIR FISHERY

In the transformation from a free-flowing stream to an impounded lake, the species composition of the aquatic environment will change. In some instances, the change will provide suitable habitat for species previously absent in the Tocks Island/Port Jervis reach of the river, but most of the river's resident species will still occur in the reservoir waters. The ecological balance will be altered, though, with a different species diversity and food web established.

The portion of the Delaware River which flows through the proposed reservoir site can be characterized as a smallmouth bass-walleye fishery. Other prime game fish include the largemouth bass, chain pickerel, and muskellunge. The largemouth bass and the chain pickerel are of very minor importance while muskellunge is rare. Channel catfish, white catfish and brown bullheads are present in the river waters as well.

Panfish, including the black crappie, white crappie, yellow perch, bluegill, redbreast sunfish, pumpkinseed and rock bass also frequent the Delaware Water Gap - Port Jervis mainstem reach. The shiners, minnows,

and daces are representative forage fish, while the carp and white sucker are typical rough fish in the river. In addition, the anadromous American shad and sea lamprey and the catadromous American eel move through the Tocks Island region during their annual migrations to and from the sea.

In all probability, Tocks Island Reservoir would experience a trend towards eutrophication which, coupled with a lack of competition due to increased space, would enhance fisheries productivity. This initial rapid expansion of fish populations due to favorable conditions for reproduction, survival, and rapid growth would create a rich fishery dominated by game fish (6-10 years). The lake character would eventually shift to a fishery with panfish and rough fish comprising the major bulk, though the more sought-after game fish (e.g., the smallmouth bass and walleye) would still be evident among the daily catches. As discussed below, rough fish control might partially offset this trend but the effectiveness of such control, especially in a lake of this size, is justifiably questioned.

The predicted standing crop of reservoir species or species groups would be made up of about 43 percent sport fishes, 24 percent rough fishes and 33 percent forage fishes (U.S. Fish and Wildlife Service, 1971). The forage fish crop prediction is based on the presence of alewives through natural occurrence or stocking. Pelagic landlocked alewives occur

in several eastern lakes and are abundant in both branches of the Delaware and the Mongaup system. Most likely, this member of the herring family would establish naturally in the Tocks Island Reservoir. Landlocked alewives are primarily plankton feeders and thus would not be dependent upon the tenuous food supply the littoral zone may offer. In addition, the landlocked alewife would serve as a major forage base for many of the prized game fish. Natural alewife die-offs at the end of their life cycle would be a negative aspect of the alewife presence if recreational beaches are affected. Similarly, alewife competition with young smallmouth bass might affect the bass population in the reservoir.

The preceding standing crop estimates by the U.S. Fish and Wildlife Service were based primarily on national averages of 103 reservoirs in the United States. Tocks Island reservoir differs from the national reservoir averages in several physical and chemical parameters as shown below in Table 9-16. The associated effects of each difference upon key fish species in the reservoir are included:

Table 9-16 INFLUENCE OF THE ENVIRONMENTAL CHARACTERISTICS UPON THE ESTIMATED RELATIVE ABUNDANCE OF POTENTIAL FISH SPECIES IN TOCKS ISLAND RESERVOIR.

Tocks Island characteristic in relation to U.S. Sample mean	Effect on Tocks Island standing crop (Significant at 0.20 level)
Greater mean depth	-positive effect on sunfishes; negative effect on carp, channel catfish, large-mouth bass

Table 9-16 (continued)

Higher water exchange rate	-negative effect on bullheads, channel catfish, largemouth and smallmouth bass and white crappie
Shorter relative shoreline length	-positive effect on black crappie; negative effect on carp, channel catfish and total sport fish crop
Lower dissolved solids	-positive effect on pike and pickerel, bluegill and black crappie; negative effect on carp, carpsuckers, catfishes and largemouth bass
Shorter growing season	-positive effect on pike and pickerel; negative effect on channel catfish, bluegill, black basses, and black crappie

The U.S. Fish and Wildlife Service concludes that the characteristics related to the proposed reservoir would encourage growth of pike, pickerel, sunfish, and black crappie populations over that which is predicted nationally, while discouraging carp, carpsuckers, bullheads, catfishes, black basses and total sport fish crop. Consequently, the actual sport fish crop could be as much as 30% below that estimated in Table 9-17.

Table 9-17 PREDICTED STANDING CROP OF MAJOR SPECIES OR SPECIES GROUPS IN TOCKS ISLAND RESERVOIR AFTER 20 YEARS OF IMPOUNDMENT

	Pounds/Acre
Sport Fishes[1]	
Trout (rainbow & brown)[2]	3
Pickerels (chain & redfin)	3
Northern pike	1
Brown bullhead	6
Catfishes (channel & white)	4
White perch	6
Sunfishes (rock bass, redbreast, pumpkinseed & bluegill)	10
Largemouth bass	3
Smallmouth bass	4
Crappies (black & white)	4
Walleye	4
Yellow perch	8
	56
Rough Fishes	
White sucker	15
Quillback	5
Carp	10
	30

[1] Prediction of muskellunge standing crop is absent

[2] Trout estimate probably does not reflect the low dissolved oxygen levels in the hypolimnion which will reduce trout production.

Table 9-17 (continued)

Forage Fishes		
Minnows (golden shiner, Notropis sp., fallfish)	5	
Clupeids (alewife)	38	
	43	
Total		129

Adapted from the Bureau of Sport Fisheries and Wildlife, 1971.

The tendency of undesirable stunted fish (e.g., sunfish and perch) and rough fish (e.g., carp and white sucker) to become overabundant under impoundment conditions might be ameliorated by present management techniques, though it is recognized that effective management is not always possible. Predators of the stunted and rough fish, as the striped bass, northern pike, chain pickerel, mushellunge, and coho salmon, can be introduced and/or stocked if suitable spawning habitat exists (e.g., the chain pecherel requires submerged vegetation in early spring).

The striped bass spawns only in the upper tidal portion of the Delaware River but year classes I and II bass seasonally move into the Trenton-Easton area during feeding migration. A portion of this movement is hindered by the DO sag in the Philadelphia area.

Striped bass transplants could potentially thrive in the reservoir if spawning in the tributaries was successful. The depth, temperature regime and water velocity of Upper Delaware River Basin waters would probably prevent large-scale recruitment. Predation on surviving larvae and juveniles may be another negative factor.

The Northern pike, chained pickerel, and muskellunge are all efficient and voracious predators. Suckers, perch, and sunfish comprise the primary food base of the esocids. Chained pickerel may be limited by the absense of aquatic or flooded vegetation though it is likely that proper spawning habitat will exist. The coho salmon would probably not effectively reduce the sucker, carp, perch, or sunfish populations, feeding instead upon the landlocked alewives. The availability of the alewife as a food source may reduce desirable predation on and control of panfish and rough fish by the esocids as well. Supplemental stocking may be needed to enhance biological control efforts. It is recommended that active stocking of fish be contingent upon the natural reservoir balance that is established. The complexities involved in any stocking program must be realized (e.g., it would probably be counter-productive to stock both trout and esocids because of predation on trout).

Seining and drawdown have been effective means of controlling certain species of panfish and trash fish. Carp spawn in very shallow waters, later in summer than most other reservoir fish (late May - June).

These fish are not nest builders and their eggs are very susceptible to drawdown and the subsequent exposure to sunlight, which dries them out. Drawdown for control during this time may be difficult to effect due to late spring run-off. Suckers are not affected by drawdown techniques as they spawn in the tributaries. Seining is not economically feasible and probably would be ineffective in a reservoir of this size. Seining of the sucker run at the river's entrance to the lake, however, is a possible working approach to sucker control. The absense of aquatic rooted vegetation is more of a limiting factor upon successful esocid spawning than reservoir fluctuations. Commercial endeavors to harvest rough fish should be encouraged.

Because level fluctuations at Tocks Island will not be severe (average of 7" to 9"/day) and considering that the conclusions reached at Yard's Creek are applicable to the impoundment (Baren, 1970), the operation of pumped storage and resulting drawdown will have an adverse effect upon few, if any, of the resident species. The conclusions reached at Yard's Creek support the contention that most fish species can adapt to fluctuating water levels. The applicability of this study, a two-year study of four two-acre ponds, to predictions of the effect of pumped storage upon the proposed Tocks Island reservoir, a 12,400-acre impoundment, must be carefully made (FAWTAC).

Implementation of management recommendations in the "Proposed Fishery Management Plans for the Tocks Island Reservoir and Its Tailwater" (draft FAWTAC report) would further improve sport fish harvest. Most notably, the supplemental creation of fish habitat (e.g., improvement of spawning areas), the possible implementation of sub-impoundments for esocid (pickerel and muskellunge) spawning and fish concentration devices (e.g., rock rubble deposited at selected areas in order to provide cover for fishes) are mentioned.

The American eel is a catadromous species, spawning in the sea and moving into fresh water to feed. The annual downriver American eel run in the Delaware may actually approach 10 million. Commercial harvest of the eel as it returns seaward in the fall, though not as productive as in past decades, does still exist in the upper basin (primarily New York). Ogden (1970) found that the American eel comprised 37 percent by weight of all fishes in electroshocker collections on the Flatbrook, confirming the prevelance of eels throughout the upper basin mainstem and tributaries. Elvers (young, metamorphosed eels) can negotiate even the crudest fishways quite readily. Once in the reservoir, a portion of the natural upstream elver run probably would remain in the impounded waters. These eels, and those moving through the reservoir, will be subject to a greater predation pressure than normally exists with the free-flowing river. The impact of this loss to the eel resource, however, is expected to be slight.

In the Delaware River, between Tocks Island and Port Jervis, trout populations are not as evident as they are in the tributaries. In general, salmonids prefer spawning in rocky swift places (riffle areas) and, thus, the New York branches of the Delaware River and cold water tributaries flowing into the Tocks Island area provide the principal trout spawning habitat.

Approximately 40 miles of the Delaware River, 9.5 miles of Flatbrook, 2.5 miles of Minisink and 4 miles of the Bushkill will be inundated and stream habitat lost. The Flatbrook is one of the best trout streams in New Jersey. In this stream, wild brook trout occur in the head waters while brown trout dominate the lower reaches. Heavy inundation will move trout fishing considerably upstream.

A two-story fishery, with the warmer epilimnion waters containing bass, crappies, sunfish, walleye, and catfish and the colder waters containing trout, is possible only if the dissolved oxygen content in the reservoir hypolimnion waters is above 5.0mg/liter and water temperature is below 70^{o}. Most Likely, a sharply defined thermocline will develop between May 1 and August 1, depending upon river flow and climatic conditions. Available information indicates that the hypolimnion will be characterized by dissolved oxygen levels too low for sustained trout yield. A large biochemical oxygen demand will exist initially due to decomposition of organic materials with the ultimate oxygen content of the bottom waters dependent upon the extent of eutrophication in later years.

Brown trout and rainbow trout, already present in certain areas of the river, could establish naturally within the impoundment if suitable conditions do exist. Since trout spawning in lakes is generally unsuccessful (the eggs are often smothered by silt), the river and tributaries would have to provide the spawning habitat for rainbow and brown trout moving out of the impoundment. Most likely, though, the reservoir will not support significant populations of trout, especially if the sea lamprey becomes a permanent resident of the reservoir.

According to the U.S. Fish and Wildlife Service, a net loss of 40,000 man-days of stream fishing per year is anticipated. The river fishery of the reservoir will be replaced by a lake-type fishery which could support 60,000 man-days per year at the national harvest rate of 0.48 pounds/hour (assuming an annual harvest of about 11 pounds/acre and routine fishery management and average provision for access). This would be equivelant to 290,000 man-days per year at 0.10 pounds/hour. Each body of water can support a particular harvest rate relative to the fishing intensity the people seek, the extent of water, and access. Most likely, the recreational needs at Tocks Island would be met with a harvest rate below the national rate, especially considering expanded access, and thus the capacity would be greater than 60,000 man-days (closer to 290,000). Nonetheless, trout fishing is a stream sport and the loss of challenging stream fishing would be an adverse impact of the proposed project.

The sea lamprey, Petromyzon marinus, is an anadromous species which spawns in the Delaware River. The adults are parasitic upon marine fishes but do not feed while migrating and die after spawning. With this type of life cycle, the sea lamprey does not threaten existing river fishes in the Tocks Island project area. Sea lampreys can successfully negotiate most types of fish passages.

The sea lamprey did become landlocked in Pepacton Reservoir. An approximate ten-year period of lamprey scarring on the brown trout in the lake was observed. Eventually, though, the lampreys disappeared, either because conditions were not favorable in the reservoir itself or there was not enough suitable spawning habitat upstream to maintain a self-sustaining population. Notably, no fishway facility was provided at Pepacton and, thus, the return to the sea and the introduction of any new adults were prevented. With a fishway at Tocks Island, however, continued recruitment is possible and sufficient spawning habitat exists above the proposed reservoir.

Lack of a sufficient population of possible prey species (soft-rayed fishes) may limit sea lamprey survival in this region, though lamprey parisitism upon spiny-rayed species has been observed. Apparently, when preferred prey species are not available, the lamprey can and will attack alternative hosts, even heavily scaled species (Hardisty N.W. and Potter T.C., 1971). Thus, it is probable that a permanent population of sea lampreys feeding on the resident fishes would establish a Tocks Island

reservoir residence if the entire sea lamprey run does not use the fishway to return to the sea. Sea lamprey control in the fishway might mitigate the adverse impacts of the parasitic eel, though this approach of lamprey control remains relatively untested.

The bass tapeworm, Proteocephalus ambloplites, is a parasite which infests a number of species present in the Delaware River, notably the small- and largmouth bass. Quiet waters are more favorable for the proliferation of the tapeworm because it is more likely that re-infestation will occur. As a result, the incidence of bass tapeworm in the impoundment would be expected to increase relative to the free-flowing Delaware. The tapeworm can affect bass reproduction by damaging or preventing effective enlargement of the gonads. Nonetheless, the actual type and extent of damage that the tapeworm has inflicted upon the bass resource of the upper basin is not clearly evident. Though the tapeworm infestations are widespread, it appears that the parasite has had no significant depletive effect on the small or largemouth bass populations in the region's waters.

Because of the number of species involved, the complexities of food web interactions, and the fact that organisms do not respond in similar ways to survival-dependent factors, there is a definite uncertainty inherent in any prediction of the eventual ecological balance in the lake. The question is further confused by external factors with uncertain impacts such as the sea lamprey and the bass tapeworm.

Fishing may be excellent in the reservoir for even a lengthy period of time. Nonetheless, frame of reference should not be lost in the discussion of pounds/acre or man-days. The potential of the Delaware River and tributaries has yet to be realized. Undeniably, the flowing waters in this region represent an extremely valuable and diverse fishery in its present condition.

IX.C.2 SHAD

The American shad, Alosa sapidissima, is a silvery-blue anadromous fish representing an extremely valuable resource of the Delaware River. Often referred to as the 'poor-man's salmon', the shad has historically been a prized commercial and sport fish.

In the 1900's, there has been selection for those shad migrating further upstream, or passing through the Philadelphia region at an earlier time in the spring, because of the summer dissovled oxygen sags in these tidal flux areas of the river. The offspring of those fish spawning in the East Branch and above the proposed Tocks Island Dam site pass through the same area later in the fall and thus have more chance of avoiding the summer DO sag, representing an additional benefit of earlier adult migration (VI.A.6.).

Adult shad require a DO of at least 2 mg/liter while young shad require 3 to 3.5 mg/liter (Delaware River Anadromous Fish Project, Annual Progress Reports, and Comprehensive Evaluation of Environmental Quality, U.S. Army Corp and Department of Interior, 1971). Sublethal effects (e.g., rapid gulping) are often associated with a DO below about 5.0 mg/liter. Correlations exist between DO levels existing during adult migration and corresponding successful recruitment of young. When the path of shad migration is blocked, the fish may move to alternate streams if available, although spawning in streams other than the natal one is generally less successful.

The U.S. Fish and Wildlife Service estimates that 60 percent of the shad run successfully passes through the DO block with only 20 percent surviving in drought years. It is predicted that 80 to 85 percent survival may be obtained by 1980 even in drought years due to pollution abatement programs. Thus, the apparent potential for the Delaware River shad run is significantly higher than the present population.

Many females return downstream after spawning, but the block in the Philadelphia-Camden area prevents most returning adult shad from reaching the ocean waters. Repeat spawning is characteristic of the American shad north of the Carolinas. The contribution by Delaware River females returning to their spawning grounds will increase markedly with eventual

pollution abatement in the Philadelphia area, though the major portion of the annual shad run will probably not live to return.

Ninety percent of the shad entering the mainstem of the Delaware River are destined for spawning grounds above Tocks Island. Spawning occurs in late May to early July in swift, shallow waters with gravel or sandy bottoms. The transparent eggs are released and fertilized, gradually absorbing water and increasing in size from about 1/16 of an inch to 1/8 of an inch in diameter. The eggs sink slowly and are carried along by the currents, hatching in 3 to 8 days depending on the water temperature.

Shad eggs can develop over a wide temperature range (13 to 24^{o}C) in a usual time span of 4 to 6 days (at 15 to 18^{o}C). Any eggs transported to the lower depths of the reservoir may take longer to hatch (within a 3 to 17 day range) but most likely will not be affected by siltation. Providing the bottom waters contain sufficient oxygen in the late spring, most egg-oxygen exchanges will not be impaired by silt due to the short duration of the egg's residence in the reservoir.

Even if gravel or sand is placed throughout the reservoir, a significant portion of the shad's current spawning grounds would be lost due to lack of sufficient flow in the shallows (approximately 37 miles). The U.S. Fish and Wildlife Service estimates that there would be an annual

commercial loss of at least 25,000 pounds due to destruction of spawning habitat by inundation. Whether water quality improvement due to pollution abatement will reverse or relax the selection pressure for those shad spawning upstream, allowing shad to use spawning grounds between Trenton and the dam, remains to be seen.

Subsequent clean-up of the fishway construction on tributaries downstream of the Tocks Island Dam, such as that proposed by the regional fisheries management in Pennsylvania to enhance the shad fishery of the Brandywine, Schulykill and Lehigh Rivers will benefit lower Delaware Basin anglers, but would not replace the spawning sites lost or ameliorate any loss to the New York shad fishery. Maintenance of spawning grounds only below Tocks Island would result in very limited populations whose young would tend to reach the Philadelphia area before the oxygen sags are dispersed.

Prime nursery areas occupied by young shad in July and August are quiet pools and very slow-moving streams. Young shad are pelagic, living in warm epilimnion and feeding on plankton and aquatic insects. The main food items include dipteran, caddis fly and mayfly lavae, nematodes and ostracods. Tocks Island Reservoir could offer young shad excellent nursery grounds if these preferred food items are in abundance.

The lower temperature limit of shad, approximately 42°, apparently sets the time limits for migration. Adults will move upstream in the spring when this lower thermal level is exceeded. Usually this migration begins

in March and continues through May. Juveniles move downstream in August through November as temperatures decrease. Upstream peak migrations, however, do not occur just after these limits are broken but rather at an average water temperature of 55°. Similarly, the determining factor motivating peak fingerling migration downstream in the early fall is a water temperature drop below 50°F. Demonstration of active avoidance of cold water by young shad of temperatures between 42 to 47° is demonstrable in the lab and observable in the field. Adult shad demonstrate a similar aversion to cold water. These abrupt avoidance movements act as a safety feature preventing the adult fish from moving too far upstream and the juveniles from remaining there too long.

Though flow velocity is not the principal stimulus for shad migration, it is definitely a factor. Shad are attracted to certain flow velocities as they must continually pass water through the gills, either by swimming or allowing free flowing water to pass over them, in order to obtain an adequate oxygen supply. Thus, minimum flow velocities should be determined for migrations through the reservoir, through the fish ladder, and downstream of the impoundment.

Because the young shad move in random fashion, often heading lazily upstream as the current carries them downstream, the ability of these fish to negotiate a large, relatively still body of water is doubted. Similarly, the shad movement upstream may be delayed or blocked by the lack of sufficient orienting currents. Nonetheless, comparable movements of these fish, more notably the adults, through large bodies of water is

encouraging. In the Columbia River basin, adult and juvenile shad pass through the Bonneville and Dalles Dams and associated reservoirs quite readily, apparently following temperature related density currents within the reservoirs. Indeed, if a lower temperature limit is the principal motivating force behind the fingerling movement towards the ocean, a portion of the downstream migration probably will be successful.

The reservoir will delay the downstream movement of the juveniles causing them to reach the DO sag later when improved DO levels are more likely. This benefit may be offset, though, as the juvenile shad will be subject to increased predation due to both the change in fish species composition and the lengthened stay in the reservoir. Chief predators of the shad are American eels, striped bass and catfish. The American eels and catfishes feed on eggs and young striped bass and crappies prey heavily on the young. As mentioned previously, it is likely that these species may be augmented and not adversely affected by the Tocks Island Lake Project. Shad fingerlings also represent a food source for the rainbow and brook trout, smallmouth and largemouth bass, and walleye. Potential stocking of the striped bass, northern pike, or muskellunge will heighten this predator pressure. Establishment of a substantial landlocked alewife population would relieve some of this lake-derived predation.

If complicating factors are superimposed (e.g., pumped storage intakes, etc.) the problem of shad passage through the reservoir is complicated. Downstream migrant bypass facilities are an integral part of successful continuation of the shad migrations. Provisions for supplying such passage facilities is addressed in a 1968 DRBC resolution #68-12 (Chapter IX.E.2).

The U.S. Fish and Wildlife Service estimates that the entire Delaware River shad fishery supplies about 125,000 man-days of shad fishing at present. They further conclude that there will be a loss of 11,000 of the 35,000 man-days of shad sport fishing estimated to occur at the reservoir site without the project. The remaining 24,000 man-days of shad fishing at the site is expected to be transferred to the river, probably above the reservoir but possibly below the dam as well. As mentioned previously, though, the potential Delaware River shad population and associated fishing effort is considerably greater than the above figures reflect. Accordingly, the estimated loss is greater relative to a realized potential of the Delaware shad fishery.

The man-day figures would be altered if any unexpected problems directly or indirectly damage the fish populations. Nitrogen supersaturation is one such possible source of trouble. Fish moving too quickly from a supersaturated environment to one with a lower partial pressure may experience conditions comparable to decompression sickness, bends, or caisson sickness as nitrogen comes out of solution.

As water moves over the dam's spillway, large quantities of air (nitrogen gas) are entrained in the flow and dissolved as the water tumbles to the depths of the plunge pool. Fish carried to these depths and then surfacing would be susceptible to the aforementioned conditions and probable death. The downstream reaches can become supersaturated with nitrogen, especially if the normal return to the gaseous state at reduced pressure and increased temperature is limited by slow moving, deep waters between supersaturating spillways. On the Columbia River, where most of the evidence for and concern with the "gas bubble disease" originates, a 70 percent loss of juvenile chinook salmon and steelhead trout during their outmigration in 1970 might have been a result of nitrogen supersaturated waters (Smith, Water Spectrum, 4V #2, 1972).

Limited quantities of water will pass through the Tocks Island tainter gates during normal operations due to diversion through pumped storage turbines. The water that does move over the spillway will only carry to a maximum depth of 33.5 feet (compared to stilling basins on the Columbia ranging up to 90 feet) and thus the pressure acting to dissolve the nitrogen will be considerably reduced. In addition, the proposed Tocks Island dam would be the only mainstream dam, avoiding the problem of long-term supersaturation created by a series of impoundments. As a result of these factors (Baren, February, 1975, personal communication) it is highly unlikely that the nitrogen gas bubble disease will affect the resident fish populations or anadromous migrations on the Delaware River.

Fish passage facilities within the United States are continually becoming more and more sophisticated. Successful passage of shad on the Columbia River is undeniable. Modification of the Ice Harbor fishway design to pass one million shad at Tocks Island (73,000 per day, 9,450 per hour, during peak migration), though a difficult task, is not an unreasonable goal (see VI.A.6). This one million figure passed on to the Corps by the Fish and Wildlife Service (Boston) regarding the number of shad the fishway must accommodate, is based on the ultimate clean-up of the Philadelphia pollution block.

The consultant recognizes the substantial amount of design work that already has been directed to the Tocks Island fishway and encourages continuing interaction between FAWTAC, the U.S. Fish and Wildlife Service, the Army Corps of Engineers, and other agencies attempting to combine biological expertise with engineering practice. Legitimate concerns with the efficacy of the attracting waters, maintenance of adequate flow through the fishways, the physical parameters of the structure itself, and the desirability of a supplemental fish hatchery are the types of questions dealt with in a coordinated effort.

Establishment of a board of consultants composed of capable engineers and biologists evaluating and modifying temporary and permanent passage, shad movement through the reservoir, and any unforeseen problems that may arise would be extremely productive.

Unfortunately, the nature of shad basically remains a mystery. Identification of the physical and chemical characteristics of the Delaware's waters which affect adult and juvenile shad have just recently been researched. Of specific value to the Tocks Island Project would be the identification and evaluation of any natural or artificial barriers or attractants to shad movement. Light, sound, electrical impulses or chemical means of aiding shad through pollution blocks, dams, or reservoirs, would be valuable to Tocks Island and similar projects throughout the United States.

The assumption that shad can effectively be controlled by sound or light is probably valid but the time constraints arising if the project is funded may limit the direct applicability of any barrier or guiding modes discovered during pre-dam research. The Corps has indicated a willingness to contribute substantial funds to lab research and shad management. The states, through FAWTAC and the Fish and Wildlife Service, are potential contributors to continuing shad research efforts.

Nonetheless, even with a successful operating fishway, the loss of spawning habitat inundated by the reservoir, the stress upon adult shad traversing a fishway and large reservoir en route to suitable spawning grounds upstream and upon young shad attempting to move downstream through the reservoir and turbines all but eliminate the possibility that the shad potential of an unobstructed river can be realized.

IX.C.3 WILDLIFE

When the reservoir is functional, wildlife associated with an aquatic environment will be benefited. Populations of muskrat, raccoon, mink, beaver, and frogs are among the recipients of an expanded habitat. Populations of water fowl, especially ducks and geese, and shorebirds will also increase. Shorebirds, especially will be more prone to use the edges produced by a regular lowering of the water level rather than routinely flying overhead as they presently do. Water surface resting areas will be substantially improved, but nearby feeding areas are anticipated to be largely depleted. Many aquatic macrophytes that provide substantial wildlife and bird feeding habitat (pondweeds, milfoils, naiads, water lilies, etc.) are considered nuisance plants by man and will be subject to control. However, any proposed control plan must be thoroughly evaluated before implementation as regards extent and method. In addition, aquatic macrophytes offer excellent insect habitat upon which several species of river fishes depend. Conditions for rooted aquatic plant growth would be somewhat less favorable in the reservoir than in the existing river basin, but macrophyte control, if utilized, may have as much of an adverse effect on the wildlife habitat quality as the change from a river to a reservoir system. Seeding the exposed shores with native species of plants during extensive periods of low water for wildlife habitat augmentations is possible. Seeding with non-native species has been successful on other reservoir shorelines, but native species planting is better, as some seeds will undoubtedly disperse to more natural parts of the DWGNRA and germinate.

Land animal migrations follow a relatively north-south alignment along the river basins. The reservoir will force the animals up onto the hills and over to adjacent areas to hunt for food. Here, the habitat is less suitable and niches currently occupied. Parking lots, campgrounds and resorts will further lessen available habitat area. The 880 acres mitigation land suggested by the Fish and Wildlife Service is not as productive a habitat and would have to be managed by plantings, clearing, and burning to increase its carrying capacity. Even with this, it would not be sufficient compensation.

Intensive wildlife management practices may lessen the impact on, but in no way be a substitute for, the habitat and food sources lost by the reservoir. These management practices should include native vegetation plantings in cleared areas and areas designated for public use,

development of wetland areas to attract shorebirds and provide shelter for waterfowl, avoidance of unnecessary destruction of wildlife habitat and vegetation, control of populations of game animals, especially deer, with varied length seasons and bag limits on doe, and restrictions on areas to be hunted.

IX.D. POSSIBLE SALMONELLA CONTAMINATION

The genus Salmonella belongs to the family Enterobacteriaceae (enteric bacteria) which includes such organisms as coliform bacteria. A large number of the 1,300 Salmonella serotypes are pathogenic and most of them are commonly found in the gastrointestinal systems of various higher animals (including man). In particular, members of this genus are known to cause typhoid fever and gastroenteritis in human beings.

The major factors affecting the growth of Salmonella are temperature, pH and the presence of predator populations. As would be expected from a genus that flourishes principally in warm-blooded mammals, the optimum temperature range for Salmonella growth is between 95-99°F (35-37°C). The optimum pH lies between 6.5 and 7.5. The presence of predator populations within Salmonella hosts is virtually non-existent. As a result, the number of Salmonella bacteria that can be found in the fecal discharges of infected hosts can be quite high (i.e., 34,000/gram of fecal matter in infected chickens).

Because these pathogenic bacteria do flourish in such high numbers in their host organisms, it is logical that the host themselves and their fecal material would comprise the major sources of infestation. The most prevalent pathway for Salmonella transmission is through the consumption of infected foodstuffs (i.e., human consumption of various food-producing animals, which are themselves infected). Another pathway is

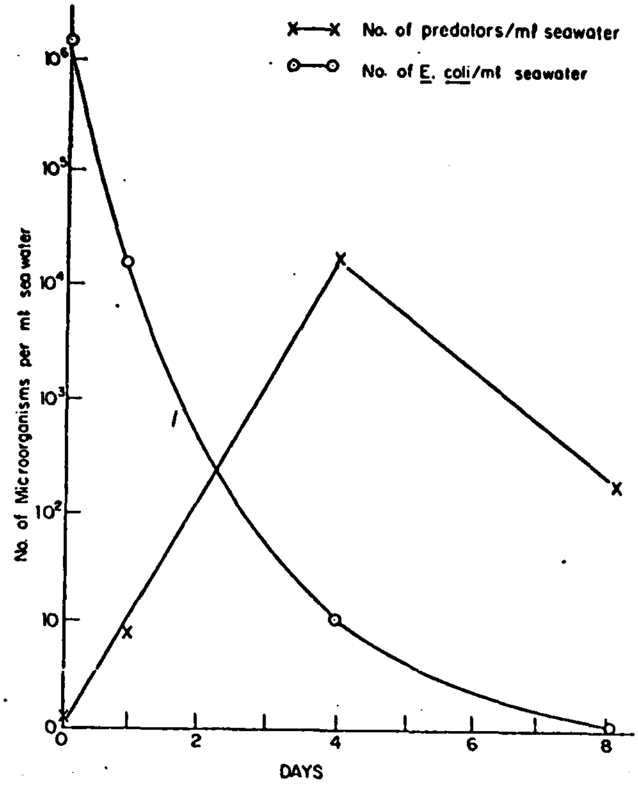
through waterborne infections, particularly arising from fecal material pollution via drinking water supplies.

With respect to the water supply users downstream of the dam site, however, the impoundment should improve the bacteriological quality of the water entering the downstream reaches. As indicated, in Chapter VI.A, impoundments improve the bacteriological water quality by providing extra residence time.

The evidence for transmission of salmonellae by means of waterborne pollution of recreational areas is, at best, tenuous. Relatively few cases of Salmonella transmission in waters used for body contact recreation have been cited and these are typically lacking adequate documentation (Dauer, et al. and Anon). This apparent lack of recreational waterborne transmission is most directly attributable to the rapid die-off of salmonellae upon their introduction into an unfavorable environment such as natural waterways. Not only are the water temperatures frequently well below those needed for optimum growth (i.e., the average summer temperature of the Delaware River near Tocks Island is 69°F (21°C), but such aquatic environments also have large populations of microorganisms that prey on enteric bacteria. Most likely, the microorganisms involved in this predator-prey relationship include other species of bacteria that are parasitic and/or amoeboid and/or ciliate protozoans. These native microbial predator populations tend to exist at low levels in unpolluted rivers but rapidly develop upon the introduction of enteric bacteria (as shown in Figure 9-8).

It would therefore be suspected that Salmonella levels in the Delaware River should be quite low. In fact, the only reason that these bacteria should be detectable at all is that feedlot runoff from poultry farms and municipal discharges most likely are providing a constant input of new organisms. Unfortunately, at the present time, no data are available to back up this contention. However, data dealing with fecal and total coliform bacteria levels do exist. Recent studies (Smith et al, 1973) suggest a relationship between the numbers of coliforms and salmonellae in natural waterways.

In the Smith study cited above, an analysis of two rivers emptying into Lake Erie in the Detroit area did show a correlation between Salmonella levels and total and fecal coliform bacteria (in particular, total coliforms). One of these rivers, the Saline River, has somewhat similar pollutional inputs to those that occur upstream from the proposed Tocks Island reservoir site. Thus, it should be possible to get a general indication of the current Salmonella concentrations in the Delaware from these correlations. In the Saline River analysis, approximately 1 Salmonella was found for every 1,500 total coliforms present. Using this ratio, and the fact that the highest concentration of total coliforms found in the Delaware River at Port Jervis between July, 1972 and March, 1974 was 4,000/mℓ, the expected corresponding maximum concentration of Salmonella organisms in the river should not exceed 3/100 mℓ. Such a concentration, particularly from the viewpoint of public health and water contact recreation, does not present a significant problem. In actuality,



Simulation of a population of microbial predators following the addition of enteric bacteria (Mitchell, 1972).

NOTE: While this particular graph involves seawater, similar relationships have been found in freshwater systems.

numerous experimental studies have shown that close to 1 million organisms typically need to be ingested before infection will occur. (McCullough et al, 1951). The unlikelihood of infestation is further supported by the fact that there have been no known cases of Salmonella infection in recreational waters in the United States which are comparable to the Tocks Island situation (Lyman and Center for Disease Control, 1975).

The proposed construction of Tocks Island lake will do nothing to increase the probability of a Salmonella problem and, in some senses, will reduce it. Since the possible sources of contamination will not change with the construction of the proposed facility, the only significant factors affecting Salmonella concentrations should be temperature and exposure to predator populations. Previous analyses by Water Resource Engineers have shown that the maximum temperature rise in the lake should be limited to roughly 3° (i.e., from 21° to $24^{\circ}C$). Such a slight increase should have no detectable effect on the relative persistence of Salmonella populations.

Similarly, in the case of predator populations, it is not expected that the construction of the lake should reduce their numbers in any way. In fact, the increased detention time resulting from the proposed impoundment, relative to the time of flow through the pre-impoundment reach of the river, should allow for greater predation upon Salmonella population by predators over the same distance. As a result of these factors and the expected levels of Salmonella contamination in the river, it is

highly unlikely that any recreational hazard will exist with respect to Salmonella.

Reference:

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2. Anon., "Typhoid Traced to Bathing at a Polluted Beach." Public Works 92:5, 182, (1961).

3. Mitchell, R. "Destruction of Bacteria and Viruses in Seawater." Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers. SA4, 425 (Aug. 1971).

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5. Smith, Twedt and Flanigan, "Relationships of Indicator and Pathogenic Bacteria in Stream Waters" Journal Water Pollution Control Federation 45 (8), 1736 (August. 1973).

6. Lyman, D.O., Personal communication, New York, Bureau Acute Cummunicable Disease Control (February, 1975).

7. Center for Disease Control, Personal communication, U.S. Public Health Service, Atlanta, Georgia (February, 1975).

8. McCullough and Eisele, "Experimental Human Salmonellosis." Journal Infectious Diseases, 88,278 (1951).

IX.E. PUMPED STORAGE GENERATION

The construction of the 1,300 MWe Kittatinny Pumped Storage (KPS) project will involve the blasting of two underground tunnels through solid rock. These tunnels will connect the lake basin with the Tocks Island upper reservoir. The pumping and generating stations and the transmission lines on the western side of Kittatinny Mountain will be underground; access tunnels between the powerhouse and upper and lower ponds will also be underground. The only above ground structures are the Tocks Island Dam and Reservoir, the upper reservoir, less than two miles of transmission lines on the eastern slope of Kittatinny Mountain, and the switchyard. Yards Creek upper reservoir will be enlarged with earth-rock and concrete-rock embankments.

The typical operation will pump water at night (15,000 cfs) and release it during the day (12,500 cfs.) Waters returning through the PSG can be utilized to satisfy downstream flow requirement or be released into the lower reservoir. Waters entering the PSG system will be removed to the upper reservoir via the selective withdrawal facilities.

Pumped Storage Generation (PSG) will involve water level fluctuations in both the Tocks Island Lake and the upper reservoir. The fluctuations under normal conditions (394 to 410 feet) due to PSG in Tocks

Island Lake is expected to be seven to nine inches. In the event that the total amount of waters were released in a single day (critical power situation), the total resulting variation in TILP would be approximately 16 inches (Baren, 1971.)

IX.E.1 CONSTRUCTION IMPACTS

The storage capacity of the enlarged upper reservoir is estimated to be about 23,200 acre-feet with a surface area of about 360 acres at full pool. Impacts resulting from the construction of the upper reservoir are much the same as those resulting from construction of the Tocks Island Reservoir (Section X.A.). The rock blasting for the tunnels and surface excavation will add to the heavy equipment noise and dust. Vegetation will have to be cleared and foundations constructed for the dikes.

The primary overall impact is the increase in land undergoing disturbance. Land for new access roads and extensions of existing roads will have to be cleared for transportation of equipment and materials. Clearings and foundations may have to be implemented to augment transmission line routes on the eastern slope, depending on how the lines are located.

Wildlife will undergo simultaneous distrubances in both the Delaware River basin and on Kittatinny Ridge. Therefore, the migration

directions of ground dwellers may be greatly limited. As stated previously, the loss of habitat is an unavoidable and in some cases, an unmitigatable impact.

IX.E.2 OPERATION IMPACTS

Pumped storage operations will expose water to solar radiation. Water is warmed in a pumped storage facility when it is transferred from an area shaded from the sun to an area exposed to the sun and when the loss due to inefficiencies in the pumping-generating cycle are dissipated to the water. The EPA has computed the dissipation of cycle inefficiency heat, in a proposed pump storage facility of nearly the same size as KMP, to raise the temperature of the upper reservoir by about 3°F. An additional 1°F may be added to the water, during the period of retention before discharge if cloud cover and wind are absent.

As discussed in IX.A, waters discharged into TILP from the PSG may serve to destratify the lower part of the lake thereby invalidating the selective withdrawal capabilities. This could be done through turbulance or convection. During the summer, waters discharged downstream may raise temperatures in the stilling basin, a maximum of 1°C. If the rise in temperature is considered adverse, cooler hypolimnetic reservoir waters may be mixed with waters leaving the PSG thereby lowering the temperature of the PSG discharge.

Experiments were done by C. Baren and H. Howlett of the DRBC to determine the effects of uniform water level fluctuations upon the spawning habits of nesting fish. Four test ponds were constructed in the vicinity of the Delaware Water Gap, less than two miles from the future Tocks Island Reservoir, at the existing Yards Creek Pumped Storage Generating Station near Blairstown, New Jersey. This was an attempt to achieve some similarity in the environmental aspects of the research. Pond #1 was set to fluctuate at 10 inches, Pond #2 to fluctuate at 16 inches, Pond #3 to fluctuate at 39 inches, and Pond #4 served as a control.

Selection of fish species to be stocked was based on the sport fishes presently found in the Tocks Island area of the Delaware River. This information was obtained from the Tri-State Fishery Study. These include bluegills, rockbass, Fathead minnows, large mouth bass, pumpkinseeds, brown bullheads, yellow perch, golden shiners, smallmouth bass, and walleyes.

Trout were not considered because the expected temperature regimen of the test ponds was felt to be beyond the natural temperature range of these cold-water fishes.

Esocids were briefly considered but it was felt that because of their voracious feeding habits they would appreciably affect the results of the experiments.

The two-year study concluded that "fish adapted to the uniform regime of water level fluctuations and were successful in spawning and hatching of eggs. Unusual problems were not apparent in the early development and growth of fish. The slight decrease in recruitment of fish observed in this study could be beneficial in most natural situations."

Concern has been expressed as to the possibility of fish entering the mechanics of the PSG system. The physical movement of aquatic organisms through the pumped storage system will be checked by screening. Screening is an effective method to deter adult fish from entering the pipes. However, there is the possibility that young shad and resident fish will be held against the screens by water pressure.

IX.F. UPPER BASIN WATER QUALITY EFFECTS

IX.F.1 IMPACT OF TILP ON THE IMPLEMENTATION OF PL 92-500

The effect of TILP on upper basin water quality requirements will depend on the planned or deferred implementation of PL 92-500. If the no pollutant discharge goals of PL 92-500 are implemented on schedule by 1985, the construction and operation of TILP would have no effect on upper basin water quality. In this case, upper basin water quality would be considerably improved from its present state and the small input of nutrients flowing into Tocks Island Lake at Port Jervis would exert very little effect on lake water quality.

However, it now appears doubtful that the goals of the Act can or will be implemented on schedule. The National Commission on Water Quality is now preparing a report for Congress on the environmental, social, and economic impact of the 1977 and 1983 requirements and goals of PL 92-500. Although it is impossible to determine the exact changes Congress can be expected to make, some changes are definitely expected. Most notable will be the probably relaxation of 1983 requirements and goals. If this does occur, the present state of waste treatment in the upper Delaware Basin above Port Jervis will probably remain the same as the emphasis of New York State is upon the northern portions of the state which consequently will receive funding priority (as per the suggestion of the North Atlantic Region).

Under conditions of secondary treatment only, the nutrient input to the lake can be expected to be much as it is today, except that it will probably increase due to population growth. As was pointed out in IX.A, this degree of nutrient input will lead to eutrophic conditions in the lake. Secchi disk readings will vary from 0.6 to 1.2 meters during the summer and some hypolimnetic waters will probably suffer a reduction in DO content of as high as 5 mg/l during the summer stagnation period. As was pointed out in IX.A, these figures are average values for the whole lake and as such may vary considerably over the lake's longitudinal axis. This degree of water quality impairment would be distasteful to some recreationists (both swimmers and boaters) and consequently restrict their use of the lake. Significant and prolonged hypolimnetic DO reductions could also be harmful to aquatic life.

According to Section 302 (a) of PL 92-500,

> Whenever, in the judgment of the administrator, discharges of pollutants from a point source or group of point sources, with the application of effluent limitations required under section 301 (b) (2) of this Act, would interfere with the attainment or maintenance of that water quality in a specific portion of the navigable waters which shall assure protection of public supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, effluent limitations (including alternative effluent control strategies) for such point source or sources shall be established which can reasonably be expected to contribute to the attainment or maintenance of such water quality.

In the light of the above discussion on the effect of present and future nutrient inputs on the recreational uses of the Lake, it

would appear that EPA has the discretionary authority to require more than the secondary treatment necessary to meet the present effluent limitations of PL 92-500. The preliminary quantification of point and non-point sources performed in IX.A indicated that point sources contribute about 50 percent of the phosphorus entering the proposed lake. These figures demonstrated that New York State's ban on phosphorus in detergents combined with 95 percent phosphorus removal at four plants could reduce the phosphorus input to the lake by about 38 percent. As these plants are located near Port Jervis, it is likely that control of their discharge would decrease phosphorus loadings to an even greater degree than indicated above.

In IX.A, a similar percent reduction in nutrient loading was shown to increase SECCHI disk readings from 0.6 to 1.2 meters to 1.2 to 2.2 meters. A Secchi disk reading of 1.5 would apparently be quite acceptable to most swimmers. The above discussion indicates that a decrease in point source phosphorus loadings could have a substantial effect on the recreational uses of the lake. Decreases in non-point source contributions, though, not covered by Section 302 (a) of PL 92-500, would have even more significant effects if such reductions were superimposed on point source reductions.

Under the Section 208 planning requirements of the Act, the effect of non-point sources of water pollution on ambient water quality will be determined and various control measures able to reduce or eliminate their contributions will be suggested. Although these 208 plans will be of immense help in determining to a greater degree of accuracy the amount of non-point source pollution entering upper basin waters, no funding has been established to insure that these control measures can be implemented.

Another important part of PL 92-500 which may have an effect on upper basin water quality requirements is the Clean Lakes Section (314) of the law. This section sets forth a program to identify and classify the eutrophic state of publicly owned fresh water lakes and to develop procedures, processes and methods to control sources at pollution and restore the quality of such lakes. The EPA Administrator can then grant funds to carry out these identified methods and procedures. Complete implementation of this section of the Act in the upper basin would improve the quality of existing lakes and reduce the input of nutrients into Tocks Island Reservoir. Because Tocks Island Lake is itself expected to become eutrophic if nutrient controls are not instituted. If no other source of funding becomes available and non-point pollution control is deemed necessary, this program could provide the funds for control of non-point pollution sources.

In summary, TILP will have no impact on upper basin water quality if the Act is implemented as scheduled and the goals of zero pollutant discharge are met in the upper basin. Again, this occurrence is extremely unlikely. The more likely event, a continuance and slight increase in nutrient input to the lake from upper basin point and non-point sources may have an effect on upper basin water quality requirements. According to the discussion of eutrophication in IX.A, these inputs will cause algal blooms and a subsequent decrease in lake recreational quality. Under Section 302 (a) of PL 92-500, such decreases in beneficial use caused by point source dischargers may be ameliorated by the imposition of stricter effluent limitations. In the case of Tocks Island Lake, imposition of 95 percent phosphorus removal requirements on point source discharges could improve lake water quality. In order to mandate such action, EPA would have to impose their discretionary powers. Non-point source control could also have a substantial impact on lake water quality, but EPA has no means at the moment to fund such activities, although 208 planning will lead to greater problem and solution definition. If the lake is built and does become eutrophic, the Clean Lakes section of PL 92-500 could provide non-point pollution control funding.

IX.F.2 FINANCIAL AND TECHNOLOGICAL IMPLICATIONS OF TILP

As determined above, TILP may have an effect on the water quality requirements of the upper basin. If EPA determines that the nutrient

sources in the upper basin are degrading the water quality of Tocks Island Lake for any of its identified beneficial uses, they have the discretionary authority to mandate stricter point source effluent limitations on nutrient discharge. The financial implications of this action would depend on the amount of water quality improvement specified. For example, complete implementation and enforcement of New York State's ban on phosphorus in detergents and 95% removal of phosphorus from four plants in New York close to Port Jervis (mentioned in IX.A) would substantially improve lake water quality.

Although 95 percent removal is technologically possible by chemcial addition and filtration, it is fairly expensive. On the other hand, lower levels of phosphorus removal (85 percent) could be obtained by different processes at a substantial cost savings. As an example, Table 9-18 shows the treatment costs (both capital and total annual) needed to provide both detrees of phosphorus removals at the four largest plants directly affecting TILP. As one can see from the table, a 10 percent reduction in removal efficiency allows a 45 percent reduction in capital costs and a 32 percent reduction in total annual costs. This example illustrates that actual system selection will have to await the treatment alternative analysis to be performed in the 208 studies.

Table 9-18 Estimated Capital and Total Annual Costs for 85 and 95 Phosphorus Removal at Four New York Treatment Plants

Treatment Plant	Design Capacity,[1] Mgd	Capital Costs[2] Dollars 85%	95%	Total Annual Costs,2,3,4 Dollars 85%	95%
Liberty	1.8	350,000	650,000	80,000	140,000
Fallsburg-Woodburne	2.4	450,000	800,000	95,000	175,000
Port Jervis	2.5	450,000	800,000	100,000	185,000
Monticello	6.0	800,000	1,500,000	210,000	370,000
Total Costs		2,050,000	3,750,000	485,000	710,000[5]

1. Presently operating at 5 to 10 percent phosphorus removal levels.

2. Late 1974 - early 1975 costs at full capacity.

3. Total costs = Capital costs + Operational Maintenance Costs + debt service.

4. Debt service was determined by assuming a 30 year amortization of capital and operating costs at a 5.375 percent interest rate.

5. As per P.L. 92-500, 75 percent of the cost of upgrading treatment plants will result from federal grant monies.

Source: "Wastewater System Alternatives", Water and Wastes Engineering, May 1974 and URS

In summary, imposition of point source phosphorus limitations will increase upstream treatment costs. Federal funding is expected to assume 75% of these costs leaving 25% payable by state and local governments. It is also likely that technological advances in phosphorus removal will reduce treatment costs.

Based on the discussion in IX.A.4, some degree of non-point source control will be needed to reduce the eutrophication potential of the lake. It also appears that a non-point source control strategy for TILP should concentrate on the urban and poultry and/or cattle feed-lot runoff generated in Sullivan and Orange Counties as these phosphorus sources contribute 23 percent and 25 percent of the total phosphorus entering the lake and have the greatest effect on lake phosphorus inputs because of their close proximity. Control strategies able to reduce the phosphorus inputs of these sources are quite different. For urban runoff, improved collection systems, detention basins and chemical addition and settling basins will be needed. Because of the diffuse and variable nature of storm drainage systems, the cost of such systems will probably be quite high. Federal funding under section 314 (Clean Lake Program) may be used to pay for such systems.

Many different types of systems and processes have been proposed for the control of feedlot wastes and runoff from the housing and land disposal areas. Such processes as aerobic lagoons, anaerobic lagoons, composting, drying and pelletizing and chemical pyrolysis have been proposed to reduce the volume and change the character of feedlot waste. Final disposal in municipal treatment plants, sanitary landfills and incinerators has also been suggested and examined. Use of manure in anaerobic digestors to produce saleable methane gas has recently received much interest. Some researchers have had success feeding poultry their own wastes after dehydration and appropriate supplementation. Although

these process are receiving greater attention, the cheapest and most widely used disposal process is still land application.

Unfortunately, land application is not trouble-free and can lead to odor and runoff problems. For instance, complaints by resort and vacation home owners about odors have forced some ranchers to apply their wastes to land when odors are least objectionable (during winter). This is a time, however, when runoff problems are most acute and degradation and plant uptake least effective. The increasing size of poultry operations without a concommitant increase in land spreading area has also lead to overspreading, greater odor problems and incomplete nutrient uptake.

Therefore, a likely control strategy in the upper basin for non-point sources might include federally-funded control of urban runoff and an improvement in the practice of feedlot waste management by land disposal. Typically, such a system for feedlot waste control would have to contain: (1) diversion terraces to prevent fresh water from flowing across production sites, manure piles and freshly-spread land, (2) settling basins to control suspended particles in runoff, (3) retention basins to catch and temporarily hold runoff and wastewater and (4) pumps and irrigation equipment to periodically empty the holding ponds and distribute the effluent on farmland. The previously used method for manure spreading would also be included. Such a system should be effective in capturing phosphorus if suspended solids and sediments from production and disposal site runoff are effectively retained on land and removed from runoff. The cost of such a system per production unit would generally

decrease as the size of the operation increases. Costs for non-point source control are highly speculative. If federal funding is unavailable and non-point source control is deemed necessary as per 208 studies, private interests will be responsible for individual clean-up operations. Federal grants issued under P.L. 92-500 cover only source control of public waste treatment systems.

It is interesting to note that as the number of upper basin feedlot operations decrease, their size increases, a trend which will apparently continue. This trend indicates that the relative economic impact of control measures will be decreasing.

IX.F.3 FISHERY RESOURCES

Resident fish composition and productivity in the upper basin will not be measurably altered since water quality trends and characteristics will be similar with or without an impoundment below Port Jervis. Movement of fish between the proposed impoundment and the free-flowing waters upstream will depend upon the type of lake fishery established and the availability of food and habitat attracting upstream river fish. Most of the species or species groups likely to characterize the reservoir fishery will tend to live and spawn within the perimeter of the lake. The white sucker is a notable exception. Rainbow and brown trout may depend upon the upper basin tributaries for both spawning and nursery habitat if a cold-water fishery is established and

maintained. As discussed in IX.C.1, low dissolved oxygen levels in bottom waters probably will prevent development of a trout fishery.

In general, there is a lack of definitive criteria upon which the beneficial or adverse effects of net biomass flow can be assessed (e.g., the actual species composition of the reservoir or eventual dissolved oxygen levels in the hypolimnion). Whatever reservoir to upper basin movement occurs as a result of TILP, the ultimate impact upon the existing fish population north of Port Jervis is expected to be slight or nonexistent.

Ultimate pollution abatement downstream could affect an overall shad reduction attributable to the dam. By extanding the annual shad population to approximately one million, it is conceivable that a greater number of shad will migrate successfully above Port Jervis. Conversely, however, pollution abatement could re-open suitable spawning grounds downstream of Tocks Island and ease or reverse the inclination towards or selection of upper basin spawning by the shad. If this occurs, improved dissolved oxygen conditions downstream may not compensate for the upper basin loss of shad due to TILP as there will no longer be an advantage for these shad to passing Philadelphia early in the spring and spawning above Port Jervis. Whatever changes in Delaware water quality or shad population structure take place, the potential shad run in the upper basin will not equal that of an unobstructed river.

IX.G. CONTIGUOUS AREA WATER QUALITY EFFECTS

In this section, the future water quality of the reservoir will be examined, as well as the water quality requirements needed to protect the beneficial uses of the reservoir waters. Also included below will be a discussion of the impact on fishery resources.

IX.G.1 FUTURE WATER QUALITY

As discussed in IX.A., Tocks Island Lake has a high eutrophication potential. If present nutrient loadings remain unabated and are allowed to grow as population increases, the reservoir will annually suffer three distinct algal blooms (spring, summer and fall). These occurrences will reduce both the recreational and fishery potential of the reservoir.

The mandate of PL 92-500 could reduce the degree and duration of bloom conditions by imposing both point and non-point measures on the waste discharges within the contiguous area and in the upper basin. As shown in IX.A.6(d), substantial nutrient reductions (approximately 50 percent) would on the average make the lake waters acceptable to most swimmers and would concommitantly

reduce hypolimnetic DO depressions. Section IX.F.2 contains a discussion of point and non-point control in the upper basin. The following discussion considers both point and non-point control in the contiguous area.

IX.G.2 TECHNOLOGICAL AND FINANCIAL IMPLICATIONS OF POINT AND NON-POINT CONTROL MEASURES

Although it is apparent that most of the nutrients entering Tocks Island Lake are carried by the spring freshet, nutrient sources within the tributary area may cause localized problems. For instance, a tributary receiving Secondary effluent (mandated by DRBC standards) and discharging into the reservoir could initiate a bloom if the concentration of phosphorus in the stream was sufficiently high. Therefore, the need for control of both point and non-point pollution sources in the area becomes evident. With regard to point source control, the water quality management program in the DWGNRA is based upon the fundamental data developed by the TIRES study (Roy F. Weston and Associates), and adopted in DRBC Resolution No. 72-2, dated March 29, 1972. The plan was then modified by the Concept Plan document dated February 27, 1973 and further modified by DRBC Resolution No. 73-5, dated May 3, 1973.

In summary, the plan is to provide tertiary treatment for those liquid wastes generated within the tributary area including 95 percent phosphate and BOD removal from those effluents entering surface waters

which are tributary to the reservoir, and to institute land disposal for those wastes to be excluded from surface waters. Applicable projects were scheduled to coincide with the opening of Tocks Island Dam or by the July 1, 1983 date specified by Public Law 92-500 for achieving the use of the best practicable waste treatment technology, whichever occurs earliest.

The need for each of the states to provide facilities for treatment depends, in the case of communities, on the presence of sewage flow receiving less than the required degree of treatment. Construction of new facilities will depend on the development schedule for each specific recreational area. Sewerage treatment within the DWGNRA will be managed by the NPS (XXII). Listed below are the facilities whose construction or upgrading has been recognized as part of Resolution 73-5.

1. New Jersey will have to provide adequate treatment for the population centers of Montague and Sandyston Townships.

2. Facilities for waste treatment and disposal will be required in the recreational areas at Sandyston and at Vancampens in New Jersey at the same time that these areas are made available for use.

3. Upland recreation areas will require facilities or connection to appropriate public systems upon initiation of use.

4. Similarly, facilities will be required in Pennsylvania to provide treatment for sewage in the population centers of Milford and Matamoras.

5. Interceptor sewers will be constructed when needed in the area between Milford and Bushkill.

6. In the case of the recreation areas at Poxono, Dingmans Creek and uplands areas, treatment facilities should be provided at the time the areas develop.

7. New York State needs primarily to upgrade the Port Jervis wastewater plant.

The effectiveness of this plan, assuming it is fully implemented, will depend on its ability to handle existing flows and those developed by DWGNRA. Information developed on the probable distribution of visitors indicates that handling the increased recreational volumes may not be difficult. According to this information, the beach areas will be attracting about one-half of all visitors. As the beach sites are concentrated in the upper end of the impoundment, collection and treatment of these wastes will be somewhat more cost-effective as economies of scale may be realized.

The engineering aspects of both advanced treatment and land disposal were discussed in VI.B.4. It should be noted again that successful application of land disposal techniques would require careful operational procedures to reduce the erosion potential. The Concept Plan contained initial cost estimates for the Tocks Island area sewage plan based on 1972 cost data. URS has updated these figures to October 1974 in order to determine the present initial capital costs of the system. Table 9-19 lists the 1974 capital costs while Table 9-20 lists the assumptions used to develop such costs. Several comparisons are interesting to note. These are: (1) the costs of land application of secondary treated sewage is less than that of advanced waste treatment and (2) the capital costs have increased about 33 percent in the two-year priod between estimates. Based on late 1974 capital cost estimates for 95 percent phosphorus removal and multi-media filtration at different design capacities ("Designing wastewater System Alternatives", Water and Wastes Engineering, May 1974) the estimated difference in capital costs between the systems mandated by present regulations and that recessary for Tocks Island Lake protection would be about 2 million and 5 million dollars for New Jersey and Pennsylvania respectively.

As stated in the Concept Plan, control of non-point sources will essentially follow EPA policies and guidelines. An EPA document, "Policy on Control of Nutrient Runoff From Agricultural Lands," dated January 14, 1972, identifies three methods for such control. These are

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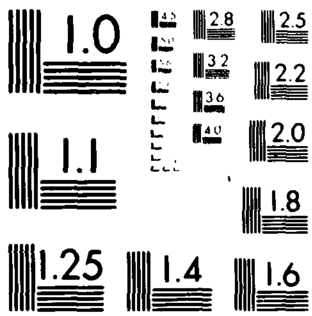


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Table 9-19 Revised Preliminary Tocks Island Area Sewerage Cost Estimates

AREA	PRELIMINARY ESTIMATED COST, MILLIONS OF DOLLARS (October 1974 levels) ADVANCED WASTE TREATMENT [1]	LAND APPLICATION BY SPRAY/IRRIGATION [2]
New Jersey		
Montague Area (1.1 mgd)	3.25	2.60
Sandyston Area (1.3 mgd)	3.77	2.99
Local Interceptors	3.54	3.54
	10.56	9.13
Recreation Area (0.87 mgd) (two major areas)	4.16	3.12
Pennsylvania		
Milford Area (8.9 mgd)	14.43	13.78
Matamoras Area (3.5 mgd)	7.54	6.63
Interceptor Sewers	20.94	20.94
	42.91	41.35
Recreation Area (0.64 mgd) (two major sites)	5.07	4.49

1. Activated sludge and High Lime Process and Multi-media Filtration and Disinfection, Aeration.

2. Preceded by secondary treatment.

Table 9-20 Assumptions for Revised Cost Estimates

1. Recreational upgrading is required at Tocks Island enclosure.

2. No difference in sewer costs between 10 1/2 and 4 million person visitors per day was noted.

3. Original costs were all of October, 1972.

4. EPA indices were used to upgrade to a later year.
   a) Philadelphia, Pennsylvania index was used primarily.

   b) Engineering News (EN) statistics were used as a check.

5. New York was assumed not to need additional facilities at this time.

6. The rate of cost increase of the activated sludge plus spray irrigation system is the same as that for the advanced waste treatment facilities.

erosion and sediment control, efficient use of applied fertilizers and retention of animal wastes on land. Control of urban non-point sources draining directly into the lake or a tributary to the lake would also reduce the eutrophication potential. Control of nutrients from such sources is expensive and considering that the major non-point nutrient input is from upstream sources, probably not necessary in terms of nutrient control.

The planned implementation of PL 92-500 will have little impact on the area. Near complete removal of BOD and phosphorus must certainly be a near approximation of best practicable waste treatment technology for municipal waste treatment plants. Land disposal would seem to meet the 1985 goals of pollution removal from navigable waters.

Because sufficient land area is available for land disposal of secondary treated and chlorinated effluent, complete compliance with the provision of PL 92-500 might be attainable in this area without significant cost penalties. In fact, preliminary calculations indicate that land disposal is somewhat cheaper than tertiary treatment for phosphorus removal. Non-point source control is also included in the plan.

Deferred implementation of PL 92-500 would have little impact on water pollution control if the waste disposal plan for the TILP is implemented. The plan indicates that 1983 standards should be met to insure the protection of surface waters in the DWGNRA.

Because the area will probably be able to meet 1985 goals at a reduced cost, it is conceivable that complete elimination of receiving stream effluent discharge could occur.

IX.G.3. FISHERY RESOURCES

The direct effects of replacing a free-flowing river and low-lying tributaries with a reservoir are described in Chapter IX.C. As delineated above and in IX.A., water quality characteristics in the contiguous area would be different under impoundment conditions. Natural and point and non-point source derived nutrients will tend to be trapped by the impoundment and cycled through the aquatic ecosystem, enhancing productivity. Even with the fully implemented PL 92-500, nutrient trapping probably would increase the productivity of the contiguous area.

Potentially harmful effects upon the aquatic biota may be associated with subsequent development of the TILP region. Toxic materials, attributable to increased amounts of urban run-off, will eventually move into the aquatic environment. Oil from heavy boating use, litter, and sewage may further diminish the quality of the reservoir waters. In general, TILP development, coupled with the DWGNRA, will place a burden upon the fishery resources of the area. Much of this burden can be mitigated by effective fishery and park management and waste disposal control.

IX.H. DOWNSTREAM EFFECTS

In this section, expected water quality and fishery resource changes will be examined. Water quality requirements for the area have already been set forth in VI.E.

IX.H.1. LOCALIZED CHANGES (TOCKS ISLAND TO TRENTON)

IX.H.1.(a) Water Quality

Operation of the dam and its outlet works will cause physical and chemical changes in the water quality of the releases and that of the downstream reach. As mentioned in IX.B., water will be released through the three tunnels, each containing a hydroturbine, during periods of normal flow at an instantaneous rate of between 1800 and 3900 cfs and an average rate of 2840 cfs or released through the tainter spill-way gates, at flood periods at much higher rates. The tunnel inlet will have selective withdrawl capabilities. The tainter gates controlling release over the spillway, will tend to release water from the top layers of the reservoir.

At the present time, it appears that very careful operation of the downstream release and pump-storage facilities will be needed in order to meet the downstream temperature objective of a $4^{\circ}C$ maximum temperature variation on either side of ambient temperature levels. As

shown in IX.A.5(1), downstream releases may have to be withdrawn from epilimnetic waters as per the temperature predictions developed through the use of the WRE model. As demonstrated in the downstream temperature graphs developed in IX.A.5(1), the greatest differences between ambient and outlet temperatures will occur during the April-July period. If epilimnetic waters are preferentially drawn, the D.O. objective should be easily met.

Operation of the pump-storage facilities may also have an effect on downstream water quality. If the return water from the pump storage reservoir is discharged to the lake, it may break up the thermal stratification near the multi-level intake. At the present time, it's impossible to determine whether or not break-up of stratification will occur and if so, to what degree. This will depend on design details not yet formalized by the respective power companies. If the chosen design could cause mixing of epilimnetic and hypolimnetic waters, the potential for violations of the downstream temperature objective would increase.

Although the coliform content in upstream waters is low, the concentration in outlet waters should be lower. Nutrient concentrations will also be reduced due to uptake by algal blooms in the water column and intervention with the sediments over the 37 mile length. Level of suspended sediment entering the lake will be reduced leaving algae as

the prime suspended material leaving the impoundment. As yet, the natural process of algal removal from river water is unknown; but, algae are known to leave the waters column after a short period of time in free flowing conditions.

The possible effect of eutrophic water release on downstream water users was discussed in IX.A.6 (e)(1). No significant effects were identified, as downstream surface water treatment plant operators expect to handle such waters easily after sufficient travel time.

The effect of nutrient reductions will depend on the implementation of PL 92-500. As mentioned previously, secondary treatment is now mandated for dischargers into the lower reach. This does not involve any significant degree of nutrient reduction. Best practicable treatment sufficient to meet 1983 treatment goals has yet to be clearly defined and zero pollutant discharge by 1985 seems almost an impossibility. Therefore, two cases will be looked at: the short-term situation without substantial nutrient reduction and the long-term ultimate case of full implementation of PL 92-500.

An idea of the short-term effect of the dam on nutrient concentrations can be gained by examining recent work done by Hydroscience, which showed that only 30 percent of the nutrients entering the downstream reach between Tocks Island and Trenton were contributed by the upstream section, which drains an area of 3827 sq. mi. About 30 percent was

contributed by tributaries draining about 1137 sq. mi. and another 30 percent was derived from Lehigh River inflow which drains 1364 sq. miles. Municipal and industrial waste dischargers contribute very little to the net nutrient inflow to this reach. According to these figures then, a 50 percent reduction in nutrient outflow from the dam would result in only a 15 percent reduction in total nutrient loading to this reach. Because nutrient inflow to the reach is primarily a function of tributary discharge from below the dam site, full implementation of PL 92-500 should have little overall effect on the relative contributions of each tributary source. The long-term effect on nutrient trapping then, should also be minimum.

IX.H.1(b) Fish

Providing that provisions for a minimum DO of 5 mg/1 and a maximum temperature variation of 8°F are met, stabilized flow might benefit the down-river fishery by reducing natural habitat destruction. In addition, the Tocks Island dam would restrict migration and tend to concentrate sport and forage fish. The temperature range of release waters will play a major role in determining the nature of the fishery immediately downstream of the dam (e.g., maintenance of waters above 68°F would be suitable for smallmouth bass and walleye while tail-waters below 70°F could support brown and rainbow trout). Avoidance of rapid fluctuations in temperature or flow is critical to sustaining any type of fishery downstream, as illustrated by damage to resident trout populations below the New York dams. Nitrogen supersaturation is not expected to be a problem for either resident or anadromous fish (IX.C.2).

IX.H.2 ESTUARY/BAY

IX.H.2(a) Water Quality

IX.H.2(a)(1) Nutrient Reduction

The expected reduction in downstream nutrient inflow will have very little effect on the nutrient content of estuarine and bay waters either in the short or long-term. Nutrient loads are derived from tributary streams, municipal and industrial waste dischargers and urban stormwater runoff. The Schuylkill, which collects surface runoff from 1863 sq. mi., is the major tributary, while smaller ones draining a total of 2743 sq. mi. also contribute nutrients. Existing municipal and industrial dischargers contribute the greatest amount of nutrients continually, while urban stormwater runoff adds considerably less due to its intermittent character.

In the short-term, nutrient trapping due to the dam would have essentially no effect due to the tremendous existing contributions from municipal and industrial dischargers. The expected long-term reduction would be slight too, as the estuary receives 4606 sq. mi. of direct drainage and 2501 sq. mi. from the upper reach of the river while collecting 3863 sq. mi. of runoff from the basin above Tocks Island.

IX.H.2.(a)(2) Dissolved Oxygen Considerations

Operation of the Tocks Island dam will have very little effect on the dissolved oxygen balance of the estuary and bay in the short or long-term. At the present time, the DO content of the estuary is controlled by municipal and industrial waste discharges. Under the waste load allocation program of the DRBC, each of these entities is allowed to discharge a certain amount of oxygen-demanding wastes into the estuary. According to their models, compliance with these allocations will allow the DO objectives to be met. One of the assumptions of the model is a monthly average base flow at Trenton of 3000 cfs. This 3000 cfs flow will be the minimum allowed during the operation of the dam. Therefore, the planning and regulating mechanisms controlling the DO balance in the short-term should not be upset.

After complete implementation of PL 92-500, the DO balance will be primarily affected by the oxygen content of Delaware River at Trenton and adjacent tributaries and not by their flow rates. Flow regulation by the dam would be expected to have little effect at this time. As the oxygen content of the bay is controlled by the oxygen content of seawater, dam operation will have no effect on bay oxygen content.

IX.H.2(a)(3) Salinity

Salinity changes within the estuary would be primarily controlled by releases from the Tocks Island Dam. As mentioned in IX.H.2(a)(2), the planned releases from the dam would meet the 3000 cfs flow objective at Trenton all year round. Therefore, it would appear that the 250 mg/l chloride

water objectives will be exceeded only during extreme drought periods.

The effect of this regulated outflow on the 15 part per thousand (ppt) salinity gradient in the bay has not been studied as extensively. The importance of this barrier is outlined below in IX.H.2(b)(2). Work done by Dr. Harold Haskins at Rutgers University indicates that the 15 ppt salinity gradient under a 3000 cfs flow rate will be maintained slighly below Arnold's bed, an oyster seed bed just below Liston Point. Historical flows during this June 1-November 1 period are both above and below 3000 cfs. For instance, during the early 60's drought, flow at Trenton dropped to as low as 1550 cfs as a monthly average. Mean monthly flows at Trenton for the years 1913-1965 are shown in Table 9-21, as are flow data for the low flow 1964 and 1965 years. These data indicate that flow regulation imposed by the dam will limit the upstream movement of the 15 ppt gradient during drought conditions.

IX.H.2(b) Fish and Shellfish

IX.H.2(b)(1) Aquatic Productivity

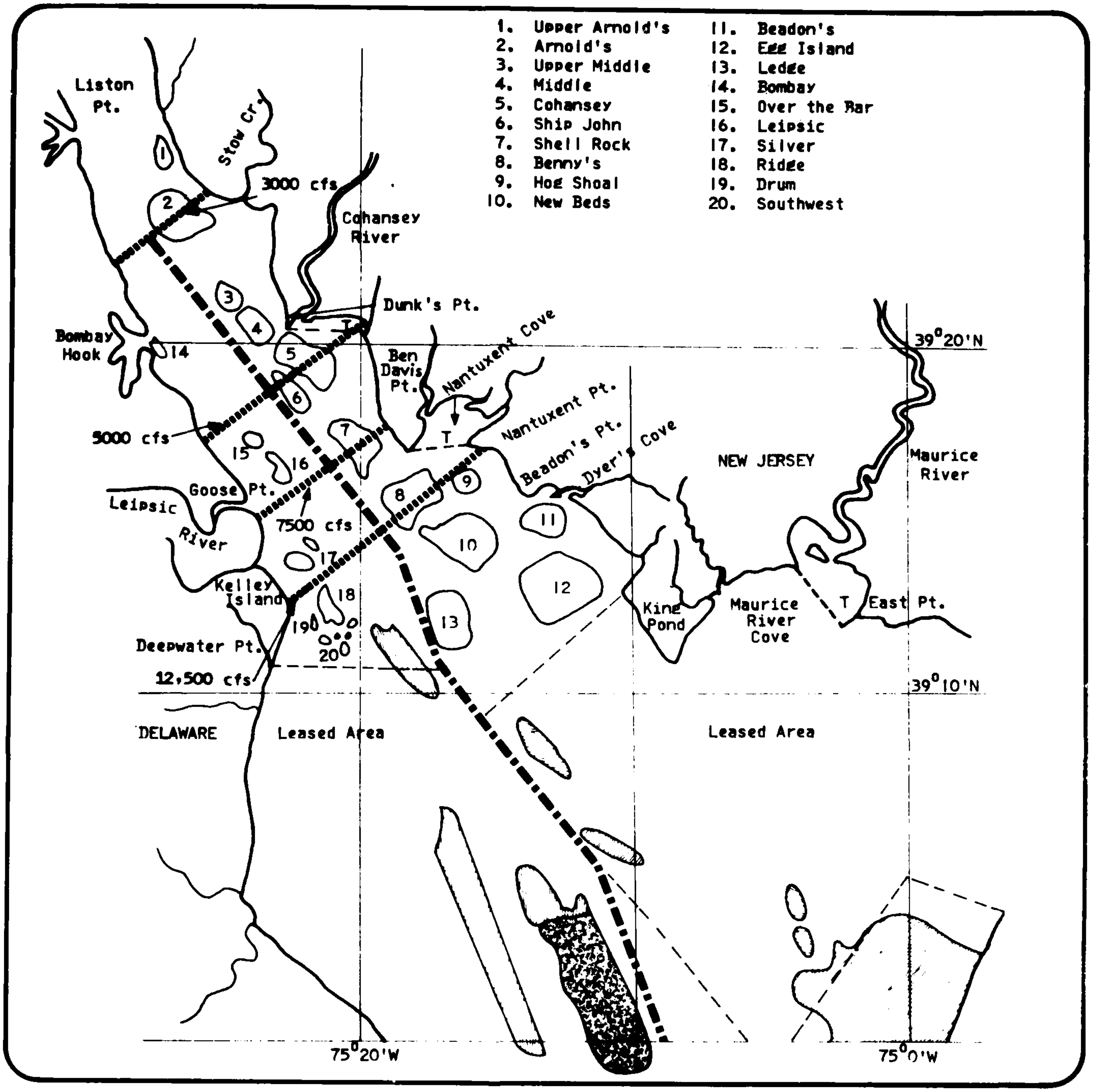
Stabilization of the physical parameters characterizing an aquatic environment will tend to make it less resilient to any fluctuations that do occur. Generally, species in the estuarine system are either capable of withstanding large salinity fluctuations or mobile enough to move with changing conditions. Maintenance of a 3000 cfs flow for an extended

Table 9-21

Observed Monthly Discharge of Delaware River at Trenton, cfs

Month	1964	1965	Average, Water Years 1913-1965
January	13,940	4,938	12,500
February	9,134	12,117	12,500
March	21,820	9,033	21,600
April	17,010	9,833	22,600
May	10,720	5,210	13,700
June	4,337	2,573	8,300
July	3,102	1,550	7,000
August	2,472	1,815	6,000
September	2,136	2,107	5,500
October	2,151	3,533	6,400
November	1,918	2,636	10,500
December	3,916	5,000	11,900
Average	7,721	5,029	11,500

* Source: DRBC 9th Water Resources Program, 1972



RELATIONSHIP OF THE 15 PPT SALINITY GRADIENT AND MONTHLY AVERAGE FLOWS AT TRENTON

IX
9

LEGEND

T—TONGING AREA

HARD CLAM

BLUE CRAB

period of time will encourage redistribution and settlement by those species unable to tolerate or avoid rapid salinity variations should they arise.

The loss of trapped inorganic and organic particulates may affect productivity in the East Stroudsburg-Easton reach of the river but will have no measurable impact farther downstream due to the magnitude of man's nutrient contribution. The absence of organic matter normally carried to the immediate downstream region may hinder the development of invertebrate communities which are the primary food source for the river's fish. Control of flooding, though serving to stablilize habitat, decreases the nutrient loading from backwater areas and floodplains.

The direct effect of TILP nutrient trapping upon bay and estuarine waters probably will be slight due to substantial nutrient contributions from other lower basin sources. Organic materials and vitamins used by estuarine and bay invertebrates may be slightly diminished. The loss of these nutrients as a result of the TILP is not considered to be potentially limiting to productivity in these waters.

More significantly, the eventual shift in nutrient balance, principally due to PL 92-500 implementation, will alter the phytoplankton species composition of estuarine and bay waters. Such a shift can have marked effects upon the species composition of the entire food web.

IX.H.2(b)(2) Oysters

The impact of MSX and mismanagement upon oyster production in Delaware Bay, along with predictions of potential harvests, was discussed in VI.A.6(b). Predation and salinity are two other variables which influence natural production levels. These two inter-related factors may be altered by TILP with subsequent effects upon the bay's oyster population.

Settling spat, only 1/75th of an inch in length, are extremely susceptible to smothering by food and space competitors and to extensive predation by a variety of organisms. Of all predators, the oyster drill is most destructive to young, thin-shelled oysters. The drill is restricted to higher salinity waters (15 ppt) than are the euroha-line oysters (5-32 ppt). This salinity restriction affords the oyster spat a relatively stress-free environment for survival and growth in the upper bay and allows substantial seed oyster production in the natural beds above Shell Rock (Figure 9-9). The importance of this barrier is borne out by an approximate 75 percent loss of transplanted seed crops in the lower bay due to predation (e.g., crabs and boring snails).

As delineated in Figure 9-9, the 15 ppt gradient penetrates considerably upstream under natural flow conditions, actually above Upper Arnold's bed during the 1964-1965 drought years (minimum monthly average flow of 1550 cfs). Despite these periodic 15 ppt incursions upstream,

the drill barrier is situated downstream between the Shell Rock and Ship John beds.

Active feeding of the oyster drill commences in mid-March and continues through November, a range inclusive of summer low flow periods and upstream salinity movement. Drill reproduction occurs in a more limited time span. Egg laying will begin when water temperature approaches 15°C late in April, will peak at 20°C in early June, and will taper off at 25°C in July. Drill eggs and young are even more sensitive to low salinities than are adults, with an 18 ppt salinity more conducive to successful drill recruitment. Thus, the salinity at the time of reproduction, which is, in turn, stimulated by temperature, determines the location of the drill barrier. Oyster drill predation is not effectively inhibited by the summer flows restricting drill activity but by high spring and early summer flows preventing their recruitment into natural seed beds above Shell Rock. By combining average monthly discharges at Trenton, Table 9-21, and the location of the 15 ppt barrier as a function of Delaware River flow Table 9-9, with knowledge of the approximate May 1-July 1 reproduction scheme, the location of the Shell Rock-Ship drill barrier can be established. The existence of a drill barrier in this region is confirmed by field observations.

As the 15 ppt gradient moves up the bay, drills can move into and feed in areas where recruitment has been prevented. In fact, drills did

inflict damage on the Cohansey bed during the 1964-1965 drought. Periodic flushing with storm-derived freshwater flows throughout the summer months can restrict post-reproduction drill movement.

The potential threat to the oyster industry by upstream storage, beyond the potential loss of food, is obvious. Reduction of freshwater input, especially between April 1 and July 1, would open the remaining "sanctuary beds" to severe predation and probably MSX infection, virtually ending the Delaware Bay oyster harvest. After the New York City diversions commenced in 1953, the drill line moved from just below Ben Davis Point almost to the Ship John bed. Approximately 1,000 acres of Delaware State seed beds and about 1,000 acres of the Shell Rock and Ben Davis beds in New Jersey were depleted by the loss of Delaware River flow. Thus, it is imperative that the agreement to pass natural river flows from April 1 to June 30 be complied with.

Stabilization of the 15 ppt gradient closer to the estuary with 3000 cfs minimum summer flows (Arnold's bed) will not have a direct adverse impact upon oyster production. A slight benefit to the oyster population during rare prolonged drought conditions may be realized. Correlation between oyster meat quality and content and summer hydrologic conditions suggests that intermittent two-to three-day periods of high flow are beneficial to the oysters (Haskins, personal communication, March, 1975). Extremely wet or very dry summers apparently produce poor condition oysters.. Upstream flushing of organic material critical

to filter-feeding invertebrate growth may be the reason for this correlation. As mentioned above, heavy slugs of fresh water during summer months may serve to diminish predation as well. Releases from storage in the late summer, if possible, would partially simulate naturally occurring surges and offset the potential damage attributable to storage of summer storm runoff.

APPENDIX A TO CHAPTER IX

APPENDIX A

THE INTERACTIONS OF ALGAL GROWTH, NUTRIENT AVAILABILITY AND CHANGES IN DISSOLVED OXYGEN

For years the dissolved oxygen concentration has been a key criterion used in determining water quality in any water body -- rivers, lakes, estuaries, or oceans. The reason is that an adequate supply of dissolved oxygen is necessary to sustain a normal ecosystem. However, it is not a sufficient condition, since the water may be well oxygenated and contain toxic concentrations of other materials that preclude aquatic life. Fish, zooplankton and benthic animals all must have oxygen to carry on normal respiration and it is available to them only as the dissolved form in the water. In order for them to survive, the dissolved oxygen concentration must not drop below a certain level.

Bacteria also use oxygen to degrade organic matter to more fundamental compounds, primarily water and carbon dioxide and inorganic nutrients. This bacterially stimulated degradation of organic matter removes the oxygen from the water, frequently reducing the dissolved oxygen concentration to well below that at which other aquatic life can survive. The organic matter in water that can be so degraded is referred to as Biochemical Oxygen Demand (BOD). The unspecified

organic material comprising BOD is even measured and expressed in terms of its oxygen uptake capacity; that is, the real concentration of the organic matter is unknown. Only the amount of oxygen that is consumed in being degraded by bacteria is observed and measured.

In any natural water system, dissolved oxygen also is the primary electron receptor; that is, the primary oxidizing agent. Because of both the large free energy change of most reactions between oxygen and many other compounds and the capacity of oxygen to receive four electrons per mole, dissolved oxygen controls the chemical potential (the free energy change in the transfer of electrons) in a natural water system, even at oxygen concentrations that are barely detectable by present-day analytical techniques. But, bacteria are capable of depleting dissolved oxygen levels to the point that oxygen is no longer the primary electron receptor. When this occurs, an entirely different set of chemical reactions can occur, most of which are stimulated or mediated by bacteria. The entire chemical environment of the system changes. Iron and manganese, which before were present as insoluble compounds contained in the sediment, are dissolved into the overlying water. A significant concentration of hydrogen sulfide (H_2S) may be produced, depending upon the pH of the water. Larger than normal amounts of ammonia (NH_3) are produced in the water from

nitrate reduction. Most importantly, as regards the eutrophication potential of any aquatic system, in some cases nutrients -- ammonia and phosphate -- are released from sediments into the overlying water where they may be subsequently available for algae growth. These processes have been recognized for some time and were clearly demonstrated by Mortimer (1969) as early as 1940.

In temperate regions of the earth, the normal seasonal fluctuation of light and temperature create a well-recognized sequence of events in most lakes. In the fall, surface water is cooled, becomes denser, and sinks to the bottom. This process, called the fall overturn, continues depending upon temperature until the entire lake reaches a temperature of about $4^{o}C$, the temperature of water's maximum density. If temperatures are low enough, the lake may freeze over, but additional circulation does not occur.

As springtime approaches, increasing levels of light and increasing temperatures warm the upper layer of the lake and provide light for the photosynthesis and growth of algae that may be in the lake. A springtime bloom (a noticeable increase in the concentration of algae) is observed in many lakes, particularly over-enriched eutrophic lakes. These algae quickly exhaust the available dissolved nutrients, cease to grow, die and sink to deeper layers of the lake.

As summer approaches the top layer is heated by sunlight and increasing temperatures and, being less dense than the cooler water below, stays on the top of the lake forming the so-called epilimnion. The deeper cooler layer is called the hypolimnion. In between is a layer where temperatures decrease rapidly with vertical distance called the thermocline.

Throughout the summer bacteria may be degrading the organic matter generated in the algae bloom that occurred earlier and, in the process, exhausting the dissolved oxygen in the lower layers. The only source that can resupply the hypolimnion with oxygen is the algae in the surface layer producing oxygen by photosynthesis and the atmosphere. The rate of reaeration in the absence of strong circulation is controlled by the rate at which oxygen can diffuse downward through the epilimnion. This 2-layer or thermally stratified condition is common, and, if it lasts long enough, the oxygen being steadily depleted by bacterial activity in the hypolimnion may be exhausted to the point that fish, zooplankton and benthic organisms cannot obtain sufficient oxygen from hypolimnion water to live.

With the approach of autumn, light levels and the ambient air temperature decrease, the epilimnion cools and vertical circulation commences. Nutrients that have been accumulating in the hypolimnion throughout

the summer as by-products of bacterial degradation may be then transported to the upper layer into the euphotic zone (the layer where light sufficient for photosynthesis penetrates) and stimulate a late summer to early autumn algae bloom. This is the classic view of the seasonal changes in temperature, nutrient concentrations, algae and dissolved oxygen in any lake and, with certain variations, it is the model most commonly observed in temperate regions.

A nutrient is any chemical constituent required by organisms for normal metabolic processes including growth and reproduction. Algae require a number of nutrients including nitrogen, phosphorus, molybdenum, silica, several vitamins and a number of trace metals. The lack of any one of those constituents can limit the growth of a population of algae (Liebig's law of limiting nutrients). In nearly all lakes reported in the scientific literature, the availability of nitrogen or phosphorus limits the ultimate size of the algal biomass of the lake. For this reason, nitrogen and phosphorus are frequently the only nutrients referred to in discussion. In most lake and river waters, the addition of one or both of these in a form available to algae will stimulate growth whereas the addition of other nutrients will not. The overwhelming observation is that nitrogen or phosphorus added to the lake will stimulate algae growth and support a higher standing biomass. In a study of nutrients that might limit algae growth in the proposed Tocks Island Lake, Fuhs and Allen (it

should be noted that Fuhs and Allen (1974) is presently in draft form and subject to revisions and criticisms) found that greatest stimulation was achieved through the addition of nitrate and phosphate. They further noted that, as bluegreen algae can fix atmospheric nitrogen, the element likely to be controlling the degree of algal growth in Tocks Island Lake would be phosphate.

The sources of nitrogen and phosphorus for the lake water are: incoming water, incoming suspended sediments, and the lake bottom sediments themselves. The incoming water carries its own load of dissolved phosphorus and nitrogen in several chemical forms, most of which are available for use by the algae. The suspended and bottom sediments contain phosphorus and nitrogen as adsorbed inorganic compounds, as structurally bound nitrogen and phosphorus, and as organically bound nitrogen and phosphorus. Fuhs and Allen (1974) found that about 15% of the total phosphorus in suspended sediments were released from them by laboratory procedures designed to indicate the fraction of sediment-contained phosphorus that is actually available for algae growth. This procedure (suggested to Fuhs and Allen by Fitzgerald) is one of several that have been designed to indicate the amount of available phosphorus. The correspondence between phosphorous actually available from the sediments and that removed by any procedure available is approximate and varies widely in ways that have not yet been adequately explained. The subject of nutrient exchange between sediments

and overlying water has been widely studied and several classic widely-read papers are listed in the bibliography. An excellent general reference is Golterman et al., 1969. Phosphorus dynamics in lakes were discussed by Rigler (1964), Olsen (1964), and Stauffer & Lee (1973). These papers are recommended reading for those seeking an appreciation for the complexity of sediment-water exchange processes.

When conditions are right -- nutrients and light are available and the temperature is not adverse -- the algae in the surface of the lake will reproduce causing a rapid increase in the standing biomass (that is, a bloom). The algal density will increase in the upper layer until any one of these potential nutrients becomes unavailable or light cannot penetrate through the bloom. Algae are restricted to the euphotic zone for growth, and a bloom is somewhat self-limiting in that organisms in upper layers shade those below. As the bloom intensifies, the euphotic zone becomes narrower and fewer organisms can be sustained. If light levels decrease due to clouds, the euphotic zone decreases dramatically forcing a greater algae die-off rate. The dead algae sink into the hypolimnion and decay causing a decrease in dissolved oxygen concentrations that may be catastrophic to zooplankton, fish and benthic populations.

APPENDIX B TO CHAPTER IX

APPENDIX B

SEDIMENT GEOCHEMISTRY AND NUTRIENT AVAILABILITY

It is well-known that nitrogen and phosphorus compounds are adsorbed to sediments. For several years, researchers have been trying to find what portion or separate phase of the sediments exercise the strongest control over the transfer of the nutrients between sediment and water, and have attempted to measure that portion of the inorganic phosphate in lake sediments that readily exchanges with the overlying water and to identify the phase with which it is associated. Jenne (1968) has suggested that the hydrous iron and manganese oxide phase present in minor amounts in most sediments (less than 10% by weight), exercise the major control over the transport properties of trace metals. It is possible that these same phases control the phosphorus and nitrogen dynamics also. This would help explain Mortimer's (1970) observation of phosphorus release from sediments when the zero oxygen isotherm reaches the sediment surface. Conceptually, when low oxygen (reducing) conditions are present at the surface of the sediments, the iron and manganese oxides that are insoluble under well-aerated conditions become soluble and release absorbed phosphates to the overlying water.

The adsorption of phosphorus and nitrogen to clays is thought to be much weaker than the adsorption to hydrous iron and manganese

oxides. The fraction of most bottom sediments identified as clay may be much larger in some cases than that identified as the hydrous oxides. Clays undergo adsorption-desorption reactions as do the hydrous oxides but do not experience changes in phase (they do not dissolve) under low oxygen (anaerobic) conditions as do the hydrous oxides. Therefore, the adsorbed phosphorus and nitrogen species, according to present understanding, would not be released from clays under anaerobic conditions.

Nutrients are cycled between water, the biota and suspended and bottom sediments. With each cycle, a fraction of the total nutrient supply is withdrawn from the cycle and permanently buried in the sediments. The common observation is that in a lake, phosphorus and nitrogen species experience a net movement into the bottom sediments. The general pattern varies according to special conditions: anaerobic conditions can cause a rapid release of nutrients from the sediments, high phytoplankton blooms can cause a rapid removal from the water, and precipitation of iron or manganese hydrous oxides in the water can remove large amounts of nutrients from the dissolved phase.

The steady net removal of nutrients to permanent burial in the bottom sediments accounts for the recovery of eutrophic lakes once the sources of incoming phosphorus have been stopped. The most frequently cited example is Lake Washington where, when sewage discharges were eliminated by diversion from the lake, recovery began and has continued despite the presence of many years-worth of excessive phosphorus buried in the lake sediments. The buried phosphorus is no longer available to algae and cannot maintain the symptoms of eutrophy.

The coprecipitation of iron hydrous oxides and phosphates has been proposed as the explanation for lower concentrations of phosphates in Baltimore Harbor than would be expected by taking into account all wastewater discharges to the harbor (J.H. Carpenter, Chesapeake Bay Institute, personal communication). Other industrial discharges containing high concentrations of iron are thought to coprecipitate with phosphates discharged from municipal wastewater treatment plants and deposit in the harbor bottom.

As we have seen, the transport of nitrogen and phosphorus chemical species between water and bottom sediments under varying conditions -- anaerobic and aerobic -- can cause dramatic changes in the concentrations of these nutrients available for algal growth. The major point to be made here is that the sediments are neither a consistent source

nor a consistent sink for these nutrients but rather a source at some times and a sink at others. Unfortunately, it is not possible at this time to predict nutrient movements in detail. Even the processes discussed at length in the paragraphs above may or may not occur in Tocks Island Lake. It would be irresponsible to suggest that any one will be predominant. The nutrient movements most commonly observed and most frequently discussed in the scientific literature are (1) the net movement of phosphorus and nitrogen species to the sediments (the rates of movement vary widely) and (2) the rapid release of nutrients from bottom sediments under anaerobic conditions. These two processes would probably occur in Tocks Island Lake.

Some reserachers believe that sediment-water exchange processes in general are more complex than the picture presented here. These workers feel that not all of the parameters determining the direction and rate of net transport of nutrients have been identified. In fact, Lee (1970) contends that not enough information, and no models are available that would adequately predict the direction and rate of transport of phosphate between sediments and water, under any given conditions. In recent discussion with Dr. Lee (G.F. Lee, personal communication, 1974) his views in this regard had not changed. Dr. Lee is one of the foremost experts in the field of material movements in natural water systems.

It is important at this time that the reader and the decision maker appreciate the complexity of this subject and appreciate the reasons why experts are unwilling to commit themselves to a dogmatic position. However, there is no question that the main source of nutrients to the lake will be the incoming water.

APPENDIX C TO CHAPTER IX

APPENDIX C

TECHNICAL DISCUSSION AND CRITICAL EVALUATION OF EUTROPHIC LEVEL MODELS FOR TOCKS ISLAND LAKE

The intention of this appendix is to provide further technical description of each of the five major evaluations of the potential for cultural eutrophication and in the proposed Tocks Island Lake.

This section points out the major aspects of the methodology used, the availability, applicability, and validity of the data available at the time the study was performed, the major conclusion of the study, the assets or shortcomings of each of the studies that reinforce or invalidate the conclusions.

The Cahill Arithmetic Accounting

Cahill made the first attempt to evaluate the potential for cultural eutrophication in the proposed impoundment. The results were presented primarily in the TIRES Study. The methodology used was overly simplistic even by 1968 standards. Cahill estimated separately the rate at which phosphate phosphorus would enter the impounded area, the rate of water inflow to the impoundment and the rate at which water would be discharged downstream through the dam. The ratio of the total phosphorus contained within the impoundment at the same time was the average total phosphorus concentration. This concentration multiplied by the amount of water

discharged over a chosen time interval was taken as the mass total phosphorus discharged downstream.

At the time of the study there were very few records available on phosphorus concentrations in the Delaware and Neversink rivers and still fewer records of phosphorus concentration in any of the tributary streams. Twenty phosphorus analyses had been performed on samples from the Delaware River at Montague between 1963 and 1968, with about 25 records taken at Marton's Creek, Pennsylvania, 1962-1962, about 10 records taken in the Delaware River at Port Jervis 1965-1966 and 1968, about 13 records taken at Hale Eddy, New York 1965-1966 and about 10 records taken at Godeffroy 1965-1966. (The quality of this data has been questioned by Dr. G. W. Fuhs because of the analytical methods used; personal communication, January 1975). With what little phosphate data was available, Cahill estimated the mean annual phosphate input through the proposed impoundment from stream flows.

Using the data generated in the TIRES study, he projected the increase in population in the Delaware River Basin through the year 2010. From these population estimates, he calculated the potential phosphorus inputs from domestic sewage over this time period, including only the population expected to be served by domestic sewage treatment plants. The phosphorus loading rate from domestic sewage was taken at 2.5 pounds phosphorus per capita per year assuming only secondary sewage treatment.

He projected the changes in agricultural land use in the upper Delaware and Neversink river basins through the year 2010 and applied a comparable factor for phosphorus contributed by runoff from agricultural land. More detail was not possible at that time. The wildfowl population was taken as constant at 40,000 ducks depositing approximately 0.45 pounds per capita per year of total phosphorus. This simplifying assumption eliminated the effect of the seasonal influx of migratory birds.

One of the alternative wastewater treatment systems recommended by the TIRES study was to have six major treatment plants providing secondary waste treatment to be built in the area, three of which

were to be located on the reservoir or tributaries to it and would discharge wastes directly into the proposed impoundment.* He projected the increase in permanent winter population and transient summer population in the four drainage basins that would be served by these three sewage treatment plants. The projections covered the period in 1975 to 2020 in five-year increments. At that time, the Delaware Water Gap National Recreation Area was expected to receive a maximum of 141,000 visitors per day in the peak of the summer season, and a total of 10.5 million visitors per year, mostly during the summer time. Using this and other data developed in the TIRES study, Cahill projected the impact of this massive influx of people on the local sewage systems and on wastewater input into the proposed impoundment.**

Combining all of the phosphorus sources -- background input from the Delaware and Neversink rivers from present and projected agricultural

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* This plan has since been substantially altered by amendment to the Comprehensive Plan of the Delaware River Basin Commission; treatment plants built in the TIRES area must provide essentially tertiary treatment, the removal of 95 percent of BOD and total phosphorus (DRBC Resolution 73-5).

** This visitor load is to be restricted to 4.0 million visitors per year (DRBC, 1973).

land use, from present and projected permanent population in the TIRES area, and from the additional domestic sewage generated by summertime visitors -- Cahill projected the rate of total phosphorus input into the proposed impoundment through the year 2020.

To estimate the input of water to the proposed impoundment, he used the flow records obtained by the U. S. Geological Survey at Port Jervis, New York, for the period 1961 to 1966. This was a period of extended drought in the northeastern United States, the recurrence interval of which has been variously estimated at from 100 to 500 years (Hull 1975). Using the phosphorus input data generated as described above and the flow records for the Delaware River, he calculated, with computer assistance, the day-to-day changes in the total mass of phosphorus and the water volume contained within the impoundment over the period 1978 to 1984. To evaluate the potential for cultural eutrophication, the average total phosphorus concentration in the impoundment was compared each day with the concentration that would be expected to generate excessive algae growth, taken as 0.015 mg/1 (.04 pounds per acre-foot) (Mackenthun 1965).

In the first year after filling the impoundment, the mean total phosphorus concentration in summer would exceed 0.015 mg/1 and thus excessive algae concentrations might be expected, according to Cahill. In the winter, concentrations would dip below this level

but by the fourth year even the wintertime average total phosphorus concentration would be above this level.

Cahill performed a similar analysis assuming tertiary treatment of all wastes generated within the TIRES area. Tertiary treatment would remove 95 to 98 percent of the total phosphorus in the domestic sewage and substantially decrease the total phosphorus entering the impoundment area. The arithmetic accounting under this assumption showed that mean total phosphorus concentrations would not exceed .015 mg/l in the summertime by the year 1984.

Although Cahill's analysis was oversimplified, it served as a suggestion that the potential for cultural eutrophication in the proposed impoundment existed. The analysis was far too simplified to be used as the basis for making a management decision about the level of waste treatment that should be provided due to domestic wastes entering the impoundment or tributaries to it, and the extent of controls applied to non-point sources in the upper Delaware River Basin. The fundamental shortcomings of Cahill's analysis are discussed below.

The Analysis Assumes Instantaneous Complete Mixing in the Impoundment.

The impoundment will be 37 miles long and it will be virtually impossible for complete mixing to occur instantly along the

longitudinal axis.

The assumption of complete mixing at least along the longitudinal axis of the lake is either explicit or implicit in all of the studies attempting to predict the trophic state of the lake, performed to date. This same assumption is necessary for a holistic view of the reservoir for predictive purposes. Unfortunately, the assumption eliminates the possibility of extracting information on the changes in trophic conditions along the longitudinal axis of the reservoir.

<u>The Flow Data Used had been taken over an Extended Drought Period</u>.

The result of using such unrealistically low flow values to represent supposedly average conditions will be to make the apparent average total phosphorus concentration in the impoundment unrealistically high. It may be expected that had Cahill continued the analysis for a few more years using flow records taken from 1966 through 1969, he would have shown the average total phosphorus concentrations to fall below 0.015 mg/1.

Phosphorus is Presumed to be a Conservative Constituent.

A questionable assumption put forth in Cahill's study is that changes in total phosphorus concentration are caused only by dilution or evaporation, and not by another physical, chemical or biological interaction. Cahill upheld that the nutrients would be recycled from the bottom sediments. However, 100 percent of the phosphorus reaching the bottom sediments cannot be completely recycled to the water column. Schindler (1974, referenced by Hull, 1974) found that in one year after fertilizing a lake in Canada with phosphorus, little or no phosphorus was returned to the lake water from the sediments even during periods of several months under anoxic conditions. Schindler's observation is not necessarily common, in that usually some fraction of the total phosphorus in the sediments is released to the water column at some time during the year.

Subsequent Planning Changes have Reduced the Potential Impact.

Resolution 72-2 from the Delaware River Basin Commission amended the Comprehensive Plan specifically to protect Tocks Island Lake from all man-made pollution discharging directly therein or to the tributaries to the lake. The amendment requires all sewage treatment plants constructed as part of the TIRES plan to provide 95 percent BOD and total phosphorus removal from the domestic sewage over the period 1980 to 2020.

The Jack McCormick Study

The study was performed under a severe time constraint that permitted little more than a review of the current literature on eutrophication and a summarization of previous studies attempting to predict the trophic state of the lake, of which Cahill's was the only one. A study by Jenkins (1971) attempted to predict the condition of the fishery that would develop but did not address the trophic state question explicitly. The McCormick study provided an excellent review of the fundamentals of limnology and of the current thinking about the causes of eutrophication.

The study group took a substantial step forward, at least in the literature review, by getting away from predicting the trophic state solely on the projected mean phosphorus concentration in the impoundment water and focusing instead on the holistic view that the potential for eutrophication is defined by the water mass, the sediments, and the drainage basin. They pointed out also that researchers had observed that morphological characteristics of the lake also affect the distribution and availability of nutrients. The most important morphological characteristic is the mean depth, since the deeper the lake the smaller the euphotic zone compared to the total volume. Also, deep lakes become stratified and nutrients settling to the hypolimnion are less available there during the summer growing season. They pointed out also that phosphorus is usually considered

the limiting nutrient because nitrogen is readily available from the air and can be fixed by blue-green algae whenever it is lacking, and the availability of carbon dioxide through the air and normal alkalinity is usually sufficient to supply all the needs of a growing algae population.

The McCormick group also realized that several natural processes tended to regulate the concentration of total phosphorus available to algae. Adsorption to particulate matter or fixation in algae cells and aquatic bacteria tend to make the phosphorus unavailable for further algae growth. The most important determinant of the degree of phosphorus enrichment is the rate at which phosphorus is transferred between the unavailable form and the available form. The efforts to improve the state of Lake Washington had shown that a substantial reduction in the concentration of algae during the prime growing season could be effected by decreasing the levels of phosphorus added to the lake from domestic wastes. Thus the study group clearly understood that natural processes in lakes tend to remove nutrients from the water and deposit them in unavailable forms in the sediments so that a eutrophic state could be adjusted to a lower trophic state by decreasing the rate of phosphorus input to the lake from external sources.

The McCormick group apparently did not have sufficient time to fully apply the newer information available from the literature to the problem of predicting trophic states. Vollenweider's (1968) work was available, and modelling technology was well documented. Likewise, they apparently did not have time to perform a substantial updating of the data base available to predict the potential phosphate load into the impoundments. As a result, they relied primarily upon the data developed by Cahill for this information.

They also expended considerable effort attempting to find a suitable model by which to make the prediction of the trophic states, but eventually decided that no adequate models were available. To quote: "The tools of microanalysis presently available are so rudimentary and the interrelationships of various processes so poorly understood that existing models are not sufficient to evaluate the eutrophication potential of Tocks Island Lake."

After the group decided that no models were available, they were restricted in their predictive methods to a variation of the methods already developed and nutrient loadings calculated by Cahill -- namely comparing the mean total phosphorus concentrations in incoming water with the criterion suggested by Mackenthun (1965). They had decided there was no way to make a prediction, taking into account the phosphorus loading rate, the mean depth and the hydraulic characteristics of the impoundment, all of the parameters they knew were important. They discussed the phosphorus concentrations in water entering the area and the potential sources of additional nutrients. The mean dissolved phosphorus

concentration in 69 samples collected below the confluence of the Delaware and Neversink Rivers measured since 1963 was .018 milligrams P per liter. Omitting the three highest values observed during period of highest runoff reduced the mean concentration to .013 milligrams P per liter.

Instead of comparing this with Mackenthun's (1965) conclusion that .015 milligrams P per liter is the phosphorus concentration likely to stimulate algal growth, they decided to rely upon another of Mackenthun's criteria, namely the total phosphorus concentration in both dissolved and suspended forms entering an impoundment is observed to be associated with excessive algal production. To estimate this total phosphorus concentration in incoming water, they assumed that the mean soluble phosphorus is one-third or less of the total phosphorus (an assumption which is questionable) so that the mean total phosphorus entering the proposed impoundment was calculated as equal to .018 milligrams per liter. This exceeds MacKenthun's criterion of total phosphorus per liter as the concentration likely to result on eutrophic conditions. This was the first eutrophic condition likely to occur in the impoundment.

The study group proposed the following argument. The mean dissolved phosphorus concentration in water entering the Cannonsville Reservoir was about 0.24 milligrams phosphorus per liter as of 1970. This lake is known to suffer heavy algal blooms during most of the summer. The mean dissolved phosphorus concentration in water entering the Pepacton Reservoir is about .05 milligrams phosphorus per liter, substantially less than that entering the Cannonsville Reservoir but three times greater than that in the Delaware River at Montague. Blooms occur in spring and summer but are nominal and present no problems. The McCormick group considered the fact of eutrophication in these two reservoirs to be germane to the prediction of the trophic state in the Tocks Island Lake.

The conclusions from the study were sketchy. The McCormick group decided that sufficient resources had not been allocated to studying the potential water quality conditions in Tocks Island Lake and that existing data was very fragmentary. But they did conclude that very gross approximations from the available data suggested strongly that the Tocks Island Lake would experience accelerated eutrophication. They suggested that the lake would look like the Pepacton and Canonsville Reservoirs if the phosphorus inputs were identical. Apparently the meaning of this statement was that all the other parameters that affect the trophic state of the lake would be the

same between the Tocks Island Lake and the two reservoirs. Since the capability for predicting the total phosphorus input to the impoundment was limited, the only certain statement they could make was that if the phosphorus loading rates were comparable, the trophic states would also be comparable.

The Water Resources Engineers Ecologic Simulation Model

In February 1973, Water Resources Engineers completed their report entitled Ecologic Simulation: Tocks Island Lake. This was the result of a sophisticated attempt to describe the ecosystem that would develop in the proposed impoundment. The methodology for making this assessment was to simulate mathematically the individual chemical, biological and physical processes expected to occur within the lake, and combine these individual simulations to present a holistic view of the system. Once the concepts of the model were formulated and programmed into the computer, six sensitivity analyses were done to show the relative response of the ecosystem to changes in the phosphorus and BOD load from background sources and from domestic sewage treatment plants.

The details of the model are far too complex to be covered in this brief discussion. A few summary sentences will, hopefully, suffice to put the major aspects of the model into perspective. The model mathematically describes the impoundment as a set of continuously stirred tank reactors (CSTR's) in which the water is well mixed and all of the reactions and interactions achieve a steady state condition. The CSTR's are stacked upon one another and the transport of material between adjacent reactors takes place by advective and diffusive processes. For the purposes of the model, the CSTR's were taken as individual layers of the lake, each two meters thick, and extending the entire length and width. A diverse and spatially varied ecosystem is not a single simple continuously stirred tank reactor, but the approach in the model is to view the system as made up of discrete elements connected in a series, that is as several CSTR's whose contents may be transferred to adjacent CSTR's. The analogy to the real environment is improved as the number of tanks increases.

Within each CSTR the biological and chemical reactions are supposed to come to a steady state. However, a real ecological system is dynamic and rarely, if ever, achieves a steady state situation. Thus, to overcome this difficulty, WRE contends that as the time interval required to reach steady state in each CSTR is shortened in operating the model, the results become more realistic.

The model takes a one-dimensional view of the water body along the vertical axis and any horizontal or longitudinal differences in composition or temperature are neglected. WRE justifies this approach by saying, "The hydrodynamic behavior of a well-stratified reservoir or lake is density-dependent, relating closely to the vertical temperature structure . . . and as such the dominant temperature gradients are along the vertical axis." This statement is certainly true for variations in temperature. It is not true for variations in chemical composition.

The first step in the model is to simulate the temperature and density structure vertically in the lake. This is performed with another model developed by Water Resources Engineers several years ago. Once the temperature and density structure have been established, the changes in concentration of a given physical, chemical or biological constituent in a CSTR is described by a set of differential equations that conserve the total mass of that constituent. In a typical differential equation, the change in mass of a given constituent is related to advection, diffusion, input, output, sedimentation, decay, resupply, chemical transformation, biological uptake, and biological release. The crux of ecological modeling is to program the computer to keep track of all the necessary bookkeeping steps. Fortunately, a problem of this complexity can be handled by the latest generation of computers. Not only have advances in computer technology been made available, but there are more efficient methods for solving large sets of simultaneous differential equations.

From a management decision standpoint, the most useful information obtainable from a model of this kind is the response of the ecosystem to external changes, the so-called sensitivity analyses. WRE programmed the model to simulate the results of the changes in BOD and phosphorus loading to the reservoir. Since they found no recorded data on BOD concentrations above the proposed impoundment, they simulated the response to four different assumed levels of BOD loading. In the case of total phosphorus inputs to the impoundment, they were able to perform sensitivity analyses wherein the input data was determined from projections of future conditions in the Delaware River Basin and the TIRES area. Six such sensitivity analyses were performed, evaluating the effect of natural background input, changes in natural background input, secondary sewage treatment and tertiary sewage treatment. The data used by WRE to represent background conditions wereobtained in 1968 after the period of extended drought from 1961 to 1966 was over. They assumed the volume discharge of sewage to the lake to be 21 million gallons per day (MGD). In the most extreme case, the amount of BOD added corresponded to the waste load from 5,000,000 persons with a treatment level that removed 80% BOD.*

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*WRE was apparently not aware of DRBC Resolution 73-6 limiting the number of visitor days to the National Recreation Area. Their simulation assumed a BOD load much larger than would be expected.

The results indicated that under 1968 background conditions the proposed impoundment would have neither heavy algal blooms nor anaerobic conditions. Sewage inputs to the impoundment from secondary treatment plants would cause nuisance growths of algae in late summer or early fall, but low oxygen conditions were not expected to be a problem even in this case. The implementation of advanced waste treatment would not result in conditions that were significantly different from the background.

Under the most adverse conditions, that is, normal background plus effluents from secondary treatment plants totaling 21 mgd, a peak algal biomass of about 2 mg/l dry weight uniformly distributed throughout the water column would be created. As in the stratified system the algae would be largely confined to the upper 2 or 3 meters. The concentration would thus be 10-15 mg/l. This would impart a noticeable turbidity to the water and the transparency would probably be about 1 meter. Another measure is that at the peak, the cell concentration would be approximately 10,000 cells per liter distributed throughout the entire water column, or about 50,000 cells per liter concentrated in the top 3 meters of water. This is a relatively small concentration compared to excessively eutrophic lakes where cell counts of 5 million cells per liter have been observed (Hull, 1974). Peak cell counts of 30 million cells per liter have been observed in Cannonsville Reservoir.

The major difficulty with simulation models based upon fundamental rate processes is that the confidence limits on the data going into the model are often rather large. Any errors that may be introduced with these constants tend to be compounded. Unfortunately, this information is lost in the complexity of the computer operation. In order to detect possible flaws in the fundamental reasoning, one must return to the original questions and the original constants that went into the model. Specifically, the ecologic simulation model can be criticized on several points.

Each Layer of the Lake must be Completely and Instantaneously Mixed.

The assumption of complete mixing in two-meter layers over the complete length of the lake erases the detail along the longitudinal axis that might be obtained by working from different postulates but is not an assumption that completely invalidates the results.

Validation of the Model may not be Adequate.

The model is said to have successfully simulated the vertical distribution of phosphate phosphorus, nitrate nitrogen, ammonia nitrogen, and dissolved oxygen in Lake Washington. Close scrutiny of the actual data and the computed values shown in Figure II-2 of the report generates some doubt. The concentration scale in each of the plots is extremely condensed; the distance between dissolved oxygen concentrations of 0 and 10 mg/l is about 10 millimeters, and the actual concentration data is represented by circles that are slightly over a millimeter in diameter. While clearly the trend lines developed by the computer are going in the right direction, the simulation is not nearly as accurate as one might ascertain from a cursory inspection of these figures. Furthermore, no attempt was made to validate the model on a similar reservoir in the Tocks Island area.

The Possible Transport of Phosphorus from Sediments may have been Ignored.

Hull (1975) points out that the differential equation describing the transport of phosphorus into the bottom layer of water in the impoundment doesnot take into account the exchange of phosphorus between the bottom sediments and the overlying water. It is possible that since the settling of matter out of the water column was considered in other equations, the failure to consider exchange between

sediments and water constitutes a defacto elimination of a source of phosphorus from the model system that is available to the real system.

Since the complete suite of differential equations was not presented in WRE's report, further evaluation is not possible. Consultation with WRE will be needed to resolve this question.

The Zooplankton Grazing Coefficient may be Unrealistically Large.

Fuhs and Allen (1974) suggest that the rate of zooplankton grazing and the rate at which the zooplankton population responds to increases in algae may be overly optimistic. They contend that the proposed lake has several properties in common with the Pepacton and Cannonsville reservoirs, that these properties are the key ones to consider in predicting the trophic state of a lake, and that zooplankton grazing does not appear to reduce the algae concentrations significantly. Both the Pepacton and the Cannonsville reservoirs show signs of eutrophication with moderate and high algae concentrations respectively appearing at certain times during the summer and early fall. In fact, very little information exists on zooplankton grazing in these reservoirs so Fuhs and Allen's contention is speculation only.

No attempt was made in this review to locate the particular differential equation or factor that simulates zooplankton response to algae concentrations.

The zooplankton population does not grow only in response to the availability of food in the form of algae. Several other factors affect the timing of the zooplankton population. Some zooplankters are found at infrequent intervals during the spring, summer and fall. Some achieve greatest fecundity in spring. Thus, the response of the zooplankton population to the algae population probably is not well represented by a continuous function, as was probably employed in the model, but by a step function or some continuous function with specific boundary conditions.

Comparing Tocks Island Lake with Similar Impoundments

Other studies that have attempted to evaluate the potential for cultural eutrophication in the proposed impoundment have taken a different approach; comparing the morphological characteristics, the phosphate loading rate, and the hydraulic characteristics of the proposed impoundment with those of other lakes that are known to be eutrophic. The mean depth of the lake reflects the overall morphology and strongly influences the amount of nutrients the lake can absorb before symptoms of eutrophy are apparent. The phosphorus loading rate, expressed in grams per square meter per year, is a measure of phosphorus input normalized to the surface area of the lake. The hydraulic characteristic exercising the most influence over the production of algae is the flushing rate. It may be expressed in any

one of several terms. One frequently used is called the hydraulic loading factor, expressed as the ratio of the mean depth to the theoretical mean retention time of the lake. It represents the rate at which a horizontal layer of water moves vertically due to the flushing of the lake. The flushing rate can often determine the trophic level of the lake. If the rate of algal growth exceeds the flushing rate, the potential biomass can be fully realized under bloom conditions. If the flushing rate exceeds the algal reproduction rate, the biomass will be washed out faster than it can grow and algal blooms will not accumulate large biomasses.

The WAPORA Study

The objective of the WAPORA study was to evaluate methods for controlling the effects of excessive cultural eutrophication, assuming that it would occur. The WAPORA group saw as one of its functions the evaluation of the extent of cultural eutrophication and so developed its own prediction of the trophic state of the proposed impoundment.

By the time the WAPORA study was conducted, substantially more data on phosphorus and nitrogen concentrations in the Delaware River and tributaries were available, enabling them to present more detail in determining the potential nutrient loading to the lake. They coupled this additional availability of water quality data with a more detailed analysis of the flow records for the Delaware and Neversink Rivers and major tributaries.

First, they were able to show for the first time that the mean flow measured at Montague represented 94 percent of the total mean flow into the Tocks Island area and only 6 percent of the flow is contributed by tributaries between Port Jervis and the dam. Secondly, they evaluated the flow records to provide monthly mean flows and used that data to calculate the theoretical flushing time of the reservoir over a period of one year. They performed the calculations for the entire reservoir assuming no thermocline in the winter and spring, and flushing of a 20-foot epilimnion between May and October.

Thirdly, they put together the most comprehensive set of water quality data to date from the results of the U.S. Geological Survey work from 1964 to 1972. The monthly mean concentrations of phosphorus, four nitrogen species, dissolved oxygen and BOD were calculated from these data. These new data also enabled the calculation of mean loading rates for total phosphorus, ammonia, nitrate, nitrite, and organic nitrogen from the Delaware River, the Neversink River, and other tributaries. This was probably the most reliable set of data on nutrient inputs to the proposed impoundment yet available.

Based upon studies by Brezonik (1972), in which the trophic states of 55 small lakes and ponds in Florida were related to the nitrogen loading rate (in grams of nitrogen per square meter of surface area per year), the WAPORA group determined that the critical nitrogen loading rate, above which eutrophic conditions would result for Tocks Island Lake with a mean depth of about 15 meters, would be of the order of 6 grams N per square meter per year. The present nitrogen loading rate, based upon the most recent data developed by WAPORA, is 36.9 grams nitrogen per square meter per year, or about 6 times the critical rate. The WAPORA group attempted to apply this same criterion to phosphorus loading rates as well. Apparently they estimated the critical phosphorus loading rate by applying the stoichiometric ration of N:P in phytoplankton (approximately 15:1) to Brezonik's

critical nitrogen loading factor of 6.0 grams nitrogen per square meter per year. Dividing this loading factor by 15 and multiplying by the ratio of molecular weights (6.8) they obtained a critical phosphorus loading rate of about 0.8 grams phosphorus per square meter per year. Assuming that 50 percent of the total phosphorus entering the lake would become available to phytoplankton and rooted macrophytes (this figure of 50 percent is not supported and appears to have been chosen arbitrarily), the mean phosphorus loading rate (apparently counting only that available to phytoplankton and plants) is about 2.2 grams phosphorus per square meter per year, or roughly 2.7 times the calculated critical loading rate. From this analysis the WAPORA group concluded that the potential for cultural eutrophication in the impoundment was large and that plans should be made to control the algae and rooted aquatic macrophytes that would develop throughout the entirety of the lake.

The WAPORA study can be critiqued on several points, the most important of which are discussed below. Each of these criticisms relates to the application of Brezonik's (1972) criteria to this prediction.

<u>The Critical Loading Factors were Determined on Florida Lakes and Ponds</u>.

It is well known that the seasonal variations in temperature in Florida are not nearly as great as those in Pennsylvania. Therefore the veritcal temperature structure and the timing of changes in

that structure in lakes in the two different areas in the country should be substantially different. Also, Brezonik's study was carried out on small lakes and ponds, probably not approximating the morphology of Tocks Island Lake.

The Use of the Stoichiometric N:P Ratio of 15:1 is Questionable.

The stoichiometric ratio of nitrogen:phosphorus in phytoplankton has a mean value of 15:1, but a range of values of 5 to 1 in conditions where phosphorus is abundant, to 35 to 1 under conditions where phosphorus is deficient (see Hull, 1975). Thus there is considerable uncertainty in the calculation of the critical mean phosphorus loading rates.

Brezonik's (1972) own Evaluation is Questionable.

Brezonik's own data indicates a tremendous amount of scatter, and his choice for the "permissible" and "critical" nitrogen loading rates as a function of mean depth is somewhat arbitrary. Fuhs and Allen (1974) have suggested that much of the scatter in Brezonik's data could be accounted for by considering the flushing rate as done by Vollenweider (unpublished) and Imboden (1974).

Fuhs and Allen

Fuhs and Allen collected additional data on phosphorus and nitrogen concentrations in dissolved and particulate matter in the Delaware River. Using their own data, they then calculated the rate of total phosphorus loading to the proposed impoundment to be 5.87 grams per square meter per year at normal pool. WAPORA had determined the loading rate to be 3.14 grams per square meter per year. Fuhs and Allen also calculated the value for the annual phosphorus load available for algal growth as the sum of the dissolved phosphorus and 15 percent (referencing Fitzgerald) of the phosphorus contained on particulate matter to be 155 metric tons per year. Unfortunately, this number, which may be a reasonable approximation of the available phosphorus, was not used for predictive purposes because their model was not derived nor verified using this parameter.

They attempted to predict the trophic state of the proposed impoundment in two ways. First, they compared morphologic, hydraulic and phosphorus loading rate characteristics projected for Tocks Island Lake with the same parameters for three eutrophic reservoirs -- the Allegheny, Cannonsville, and Wahnbach (West Germany). Their data is shown in Table 9-16. Tocks Island Lake is slightly shallower, has a somewhat higher phosphorus loading rate, and flushes more rapidly than the three reservoirs used for comparison. Shallowness and high phosphorus loading rates tend to increase eutrophy and higher flushing rates tend to decrease it.

Table 9-16 Hydraulic and Phosphorus Loading Data for Proposed Tocks Island Reservoir and Three Eutrophic Reservoirs

Name of Reservoir	Pool Elevation above Mean Sea Level	Surface Area	Mean Depths	P Loading	Theoretical Mean Retention Time	Hydraulic Loading Factor
		A (hectares)	$\bar{z}$ (m)	L_P ($g.m^{-2}.y^{-1}$)	t_w (y)	$q_s = \bar{z}/t_w$ ($m.y^{-1}$)
Tocks (WAPORA) loading factor	410	5,028	13.1	3.14	0.127	103
Allegheny[1]	max. summer pool	4,832	14.5	4.13	0.290	50
Wahnbach[2]	maximum pool	215	19	2.30	1.04	19
Cannonsville[3]	?	1,943	19	4.26	0.58	33

1 data for May-December 1972 from U.S. Army Corps of Engineers (written communication)

2 from Bernhardt et al. (1973)

3 Preliminary Report, March 1974, National Eutrophication Survey, USEPA National Environmental Research Center, Corvallis, Oregon

Source: Fuhs and Allen, 1974. Limiting Nutrient Study of the Delaware River at Montague in Relation to the Proposed Construction of Tocks Island Reservoir. Preliminary Draft, State of New York, Department of Health.

Direct comparison of these lakes is difficult. It is not possible to determine, without the benefit of Vollenweider's or Imboden's models, whether the differences between the lakes, which are especially great in the hydraulic loading factor column, balance each other or whether one factor dominates the trophic state. The trophic characteristics of Cannonsville Reservoir have already been discussed. The Allegheny and Cannonsville reservoirs resemble each other in many respects, particularly in the density and timing of algal blooms. The Wahnbach Reservoir (Berhardt et al., 1973) developed spring and summer blooms, reaching peak concentrations of 220 cubic millimeters per liter (about 220 milligrams wet weight per liter).

Secondly, from the work of Vollenweider relating the trophic state of a lake to the phosphorus loading rate, the mean depth, and the hydraulic loading factor, Fuhs and Allen determined the "permissible" and "dangerous" loading rates and the ratios of the actual or projected loading rate to the "permissible" and "dangerous" rates in the proposed Tocks Island Lake. For purposes of comparison these same parameters were calculated for the Allegheny, Cannonsville, and the Wahnbach reservoirs. The results of these calculations are shown in Table 9-17 Note that the "permissible" and "dangerous" loading rates are calculated as a function of the hydraulic loading factor q_s. It is also important to realize that the terms "permissible" and "dangerous"

Table 9-17 Dangerous and Permissible P Loadings on Proposed Tocks Reservoir and Three Reservoirs with Similar Phosphorus Loading Factors

Name of Reservoir	P loadings (L_p) ($g \cdot m^{-2} \cdot y^{-1}$)				
	L_p (actual or projected value)	"permissible" 1)	L_p / "permissible"	"dangerous" 1)	L_p / "dangerous"
Tocks (WAPORA)	3.14	0.87	3.6	1.7	1.85
Tocks 410 ft	6.07	0.87	7.0	1.7	3.57
Allegheny	4.13	0.7	5.9	1.4	3.0
Cannonsville 2)	4.26	0.55	7.7	1.05	4.05
Wahnbach (Maximum pool)	2.30	0.45	5.3	0.9	2.7

1) "permissible loading = $0.1 \times q_s^{0.5}$ (q_s in $m \cdot y^{-1}$). The term "permissible" implies a phosphorus loading rate not expected to cause eutrophy.

1) "dangerous" loading = $0.2 \times q_s^{0.5}$. The term "dangerous" implies a phosphorus loading rate above which eutrophy is expected. It does not mean dangerous in any other sense. (Vollenweider, in press)

2) preliminary data, USEPA, see footnote to Table 9-1.

Source: Fuhs and Allen, 1974. Limiting nutrient study of the Delaware River at Montague in relation to the proposed construction of Tocks Island Reservoir. Preliminary draft, State of New York, Department of Health.

refer to phosphorus loading rates below which eutrophy is not expected to occur and above which eutrophy is expected, respectively. They do not imply a public health danger, an unaesthetic condition or even an undesirable condition.

In addition, Fuhs and Allen performed the same sort of calculations based upon the model recently published by Imboden (1974) that predicted lake productivity based on phosphorus loading, mean depth and hydraulic loading factors. This model placed the tolerable loading for Tocks Island Lake between 0.2 and 0.5 grams phosphorus per square meter per year, or about one-tenth of the projected loading.

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X.A. CONSTRUCTION IMPACTS

X.A.1 CONSTRUCTION IMPACTS - VISUAL QUALITY

The aesthetic impacts potentially attributable to the construction phase of the Tocks Island Lake Project will be either primary or secondary. Primary impacts will be principally those attributable to the clearing and grading of the site, and the erection of project-related structures. These impacts will consist of the visual effects of construction activity, and the visual elements (structures) that are the products of those activities. Secondary aesthetic impacts will be attributable to construction-related activities essential to the implementation of the project. These activities include conspicuous transportation of men and materials to the TILP site, and any ancillary offsite storage or service activities.

These types of aesthetic impacts are experienced primarily by viewers of construction activities and the resulting structures. These impacts have their strongest implications for viewers with the greatest and/or most sensitive exposures, especially local residents. Visual impacts experienced by more transient viewing, including travelers and tourists, may also be considered significant.

The degree of impact perceived by an individual viewer will be affected not only by his sense of identification with the area, the site, and the project, but by the actual visual effect of TILP structures and activities at the site. In general, the visual effects of

construction will be perceived to be greatest where they create the most dramatic alteration of areas of high scenic quality. Because of the overall high scenic quality of the study area, the extensive alteration of land forms and removal of vegetation due to clearing and grading during the TILP construction phase, the primary aesthetic impact of these activities may be considered significant and negative.

Primary aesthetic impacts due to the project related structure will be more localized and, at the preliminary design phase, appear to be sensitively treated. Therefore, while these impacts are substantial, it is unlikely that they will be entirely negative.

Secondary impacts due primarily to transportation and related effects of other service activities will not extend appreciably beyond the construction period.

X.A.2 CONSTRUCTION IMPACTS UPON VEGETATION

Assuming construction procedures are similar to those that have been used for other reservoirs in the region, over 10,000 acres of vegetation will be cleared for the construction of Tocks Island dam and reservoir. Additional vegetation will be lost as a result of highway and powerline relocation. Riverbank and lowland growth will be most affected by the reservoir. Powerline and highway relocation will have more impact on the upland growth.

Riverbank growth includes the flood plain, woodland, the specialized herbaceous flora of the gravel, sand and shores of the river, and freshwater marsh. River birch, American elm, sycamore, cottonwood and willow are common trees that will be lost from the riverbanks. Fringe tree, a relatively rare floodplain tree, has been observed only on Depue Island, below the dam site; however, other specimens may be in the construction area, especially on the New Jersey side where past fieldwork has not been extensive. Riverbank shrubs to be cleared include, raspberry, blackberry, mountain laurel and rhododendron. Many interesting wildflowers will be lost when the floodplain is inundated. The most conspicuous is purple loosestrife, an introduced species, but many indigenous varieties with less widespread distributions will be depleted as well. Noteworthy floodplain wildflowers expected to be adversely affected by the project include some rare orchids; spreading globe flower, which is locally rare but common in other parts of the country; bee balm, now considered rare and indian paintbrush, which is still relatively common, but has decreased

noticeably in recent years. Although most marsh plants are not themselves rare, a significant percentage of the locally occurring freshwater marsh is in the planned impoundment. Thus, freshwater marsh would be depleted.

In the lowlands beyond the floodplain, the impoundment will replace natural and planted woodlands, cultivated fields and orchards, pasturelands and old fields in various stages of reversion. In naturally wooded areas, trees to be cleared include most of the riverbank varieties, as well as tulip poplar, black walnut, butternut and hickory. Planted trees that will be cleared include white pine, red pine, Scotch pine, white spruce and European larch. Most of these trees have value as lumber or pole timber. Inundation will eliminate the timber potential. The timber cleared from the site will be sold, and vegetation will be disposed of in the most economical and legal fashion.

Only about 100 acres of cultivated land will be inundated. Old fields in varying stages of reversion now cover most of the lowlands area that will be in the impoundment. In the most recently abandoned fields, most of the vegetation that will be lost is introduced and has little significance in terms of the regional flora. Vegetation to be cleared from the less recently abandoned fields is more diverse and includes various native and introduced varieties. Numerous red cedar, black locust and grey birch trees will be cleared from the old fields. These varieties have some commercial value and it would be wasteful not to use this timber, even if only for fire wood. Old fields in later stages of reversion are quite similar to natural woodlands and the impacts would be similar to theirs noted above.

There are many shrubs and wildflowers in all but presently cultivated and the most recently abandoned fields. Many relatively rare orchids may be destroyed. The surface of the impoundment will reach only the lower slopes, cliffs and ravines and most clearing will be confined to the lowlands.

Cliff talus and ravine plant varieties are especially interesting and are quite limited in distribution. Most of the cliff vegetation will be preserved, but the lower elevations will be inundated between Dingman's Ferry and Milford. Specialized herbaceous plants subject to impact may also include mountain spleenwort, a fern that is relatively rare but probably found only above the level of construction, goats' rock harlequin and the native prickly pear cactus. Another relatively rare fern, the walking fern, is expected on the limestone outcroppings at the base of the cliffs and some specimens will probably be lost. The ravines support major undisturbed plant growth. The impoundment will encroach to a slight degree into Hornbeck's, Van Camp's and Tillman's ravines and while the areas of greatest botanical interest will be preserved, some ravine vegetation will be lost. Oaks, red cedar and hemlocks on the northern slopes, and white pine on the southern slopes are among the trees that will be removed or inundated. Brush, wildflower and old field vegetation are more prevalent in the lower reaches of the ravines.

In addition to the loss of botanically interesting and commercially valuable species, vegetation clearing has various other impacts on the environ-

ment. The severest impact is the loss of terrestrial wildlife habitat. Vegetation clearing removes food, shelter, cover and shade, leaving a habitat suitable for very few wildlife species and this only until the area is flooded.

Erosion is another problem resulting from clearing. Even if replaced immediately, soil will be washed into the river causing siltation and turbidity problems. Cut vegetation will certainly be washed downstream, even if care is taken to dispose of debris promptly. Debris may cause local flooding downstream, navigation may be impaired, and added nutrients may cause eutrophication of the lake. Loss of potential timberland and land for cultivation is an additional impact.

Highway and powerline relocation will require clearing upland forests, old fields in various stages of reversion and possibly scrub oak barrens. Many varieties of hardwoods of both northern and southern origin will be removed for construction. Oak, tulip poplar, maple, black cherry, beech, hickory, white pine and hemlock are among the most common. Some shrubs and many varieties of wildflowers will also be adversely affected.

Upland old field vegetation is somewhat different from that of the lowlands. White pine, white birch, aspen, sassafras and pitch pine are subject to clearing in intermediate stage old fields. In late reversion stages, old field vegetation is very similar to that of upland forest. Some old field timber would be worth salvaging for commercial use.

In previously burned areas with poor soil, scrub-oak barren plant growth may be disturbed. Although this vegetation has little commercial value, it is an interesting example of plants adapting to adverse conditions. This vegetation is relatively rare, and any clearing would eliminate a substantial portion of it.

Vegetation clearing will leave bare areas, increasing erosion and runoff. The erosion problem is especially hazardous at the edges of slopes where instability could result in landslides.

The DRBC asserts that the contract for the work will stipulate minimizing the impact of construction by requiring that:

a. Penstocks and transmission lines be constructed underground.

b. Construction work areas be minimized.

Design Memorandum 10 provides that construction contracts will include rigid controls of construction methods in order to minimize and confine the destruction of existing vegetation and unnecessary grading of the landscapes.

X.A.3 CONSTRUCTION IMPACTS UPON FISH

The principal construction impact of the Tocks Island Lake Project would be damage to resident fish populations by turbidity degradation associated with dredging, excavation, road-building, and vegetation removal.

Sediment can harm fish populations by: (1) destroying the food resources (e.g., algae, invertebrates, detritus) of bottom feeders; (2) reducing dissolved oxygen due to the increased biochemical oxygen demand of the organic load; (3) having direct turbidity effects (e.g., making it difficult for the fish to find food); (4) destroying spawning grounds; and (5) adding a toxic load from the introduced sediment. If the sediment load is unusually severe, direct damage to the gills or eyes of fish immediately downstream from the construction site is possible.

The most significant periods for sedimentation effects upon the fish are obviously those stages of construction most likely to cause erosion and stream loading discussed in the water quality section of Construction Impacts (X.A.5). These phases include the dredging operations, diversion of the river through a temporary channel on the Pennsylvania side of the river, storm conditions after lengthy periods of excavation, and brush clearing.

It is difficult to determine the actual magnitude of the sedimentation impact upon the fish since, at present, the Delaware River experiences quite heavy sediment loading during storm conditions. It is doubtful whether turbidity degradation due to construction would be greater than the heaviest loading imposed by nature. Nonetheless, construction periods of potentially high sediment loading should not coincide with peak runs of the American shad (adult migration upstream in the spring and juvenile movement downstream in the fall).

Dredging and filling in the immediate vicinity of Tocks Island will eliminate invertebrate populations and any spawning ground. Photosynthetic activity of aquatic-rooted vegetation may be decreased by the siltation load and seedlings may be covered. These plants provide excellent habitat for populations of aquatic insects which serve as food sources for many of the river's fish.

The residual wastes from construction (e.g., oils, herbicides, and insecticides) most likely will not have a detectable adverse impact upon the fisheries downstream. Any types of catastrophic spills or illegal flushing action of these materials, however, will have localized deleterious effects.

The impact of sedimentation on the oyster industry is expected to be light or nonexistent. The sediment load reaching the invertebrate

population will not be extensive. Available oyster-setting cultch may be lost and there may be a decrease in feeding efficiency due to the sediment load; nevertheless, direct destruction of oysters or oyster spat is highly unlikely.

Compliance with proper operating procedures aimed at minimizing stream turbidity (e.g., monitoring throughout the construction period) would definitely diminish the likelihood of detectable damage to the fish populations.

Evidence indicates that the anadromous shad will not readily pass through orifices. In addition to the lack of light as a deterrent to passage, the flow velocities in the tunnels would prevent successful upstream shad migration. Thus, an alternate pathway for the passage of shad during the tunnel diversion phase of construction is needed. Since the shad population of the Delaware River is basically not composed of repeat spawners, successful passage of a significant portion of the migrating adults upstream and juveniles downstream is necessary each year. A one- or two-year loss of recruitment could seriously jeopardize the existence of shad fishery in the Delaware River.

In general, shad do not respond well to handling. The efficacy of trapping and trucking the shad is doubted. The high mortality experienced in past movements, though possibly attributable to poor

management techniques, and the logistics involved in moving maximum daily runs over the highways and roads apparently make this method impractical. Lifting by lock or elevator with a fish collection and trapping facility, similar to or preferably part of that required for the permanent fish passage facility, may prove successful.

Whatever passage method is employed, however, adequate water flow and oxygen levels must be maintained as shad are unable to pump water across their gills in the manner of most other teleost fish. Therefore, any temporary passage facility should be so constructed that no "dead" water results during any phase of the shads' passage. It has been observed that shad will seek to return to a flow environment when moved to still waters.

A water-lubricated chute may be the best means of transporting the shad from the top of the dam to a shallow impoundment downstream. The potential damage to the shads' scales due to movement through such chutes must also be considered.

Flow velocities through the temporary construction channel (Pennsylvania side of the shear key) may prove to be too rapid for the fish to negotiate. This problem can be mitigated by placing large boulders in the channel to interrupt the flow thereby providing resting areas for the migrating fish.

The subtleties and complexities of temporary passage are more aptly described by those fisheries biologists familiar with construction phasing, technical constraints upon passage, and having had previous experience in

similar cases. Thus, the precise mode of temporary passage of fish should be established by FAWTAC, the Corps of Engineers, Bureau of Sport Fisheries and Wildlife, and other qualified consultants working in concert. Cooperation by these agencies in establishing the most efficient means of passing the shad may prevent a disastrous loss of a unique and valuable resource in the Delaware River.

X.A.4 CONSTRUCTION IMPACTS UPON WILDLIFE

The construction of the proposed dam and reservoir will require the clearing of approximately 10,000 acres of terrestrial habitat. The land is primarily forest or woodland (approximately 78 percent), the remainder being agricultural and abandoned farmlands. Destruction of this extremely productive habitat, which supports a large diversified array of terrestrial and amphibious vertebrates, will decrease the resident populations and may reduce the species diversity of the area. This type of wildlife loss is expected because adjacent niches are at or near carrying capacities. There is also the potential for regional elimination of rare or endangered species.

A complete species inventory is not provided, as information gathering is complicated by daily and seasonal movement into and out of the project area, the scarcity of rare or fringe species, and the extensive species diversity associated with the study area. In addition, a listing of all the potential and actual inhabitants in the Tocks Island area would not clarify the construction impacts upon wildlife. Rather, the loss of habitat to those animals of particular interest due to their special status, prominence, or value as game will be examined.

The most prominent mammal is the white-tailed deer. Its present

density is extremely high (approximately 7,000 in the area to be cleared), despite heavy hunting pressures. In addition, moderate numbers of porcupines, squirrels, hares, rabbits, raccoons, opossums and other small mammals inhabit the area. Varying populations of fur-bearing animals such as the muskrat, beaver, otter, mink, red fox and grey fox are also present in the study region. These populations have increased rather markedly in recent years due to the decreasing demand for their pelts.

Amphibians and reptiles indigenous to the Mid-Atlantic States are in abundance. Frogs, toads and salamanders are the prominent amphibians, while turtles, snakes and lizards represent the common reptile inhabitants. The northern copperhead and timber rattlesnake are the only venomous snakes in the area.

The river valley is intermittently used as a flyway by several migratory species of waterfowl such as Canada geese and many species of ducks. Shorebirds migrating through the area include sandpipers, Wilson's sniper and killdeer. Excellent populations of ruffed grouse, ring-necked pheasants and wild turkey exist on both sides of the river. Hawks, short-eared owls and southern bald eagles also move up and down the valley. The mallard duck, black duck, wood duck, American merganser and a wide variety of passerine species are among those birds which also use this area for nesting sites. Woodcocks are common migrants through this region and are found in the wooded bottomlands along streams, wet pastures and brush areas. This game bird appeals to

a limited number of hunters and nests only occasionally within the project area. Noise from construction vehicles will have an impact on wildlife occupying the adjacent lands. Undoubtedly, the noise will drive many animals farther away from the project site, particularly birds, resulting in further crowding and competition for habitat in contiguous areas. It is certain that animals will be killed as a direct result of land-clearing and construction. This applies principally to those species unable to escape heavy equipment used to clear vegetation. Burrowing animals may be covered where earthmoving is substantial.

The white-tailed deer population will be most adversely affected as the valley provides their predominant food source. Where lowland terrain is lost, the deer will be forced into upland areas and other habitats less likely to support a heavy population. The upper reaches of the reservoir, in particular, would be bound by cliffs on the Pennsylvania side and fairly steep slopes on the New Jersey side which would severely limit the potential for bottomland habitat expansion. The browse in these adjacent areas is relatively poor, owing to the late reversional stage of the forest. The 880 acres presently planned to mitigate this situation will not be sufficient to support the deer population currently occupying the 10,000 acres to be cleared.

Overcrowding will produce competition for special habitat areas currently nearing carrying capacity. The net result will be a decrease in deer population of the area.

This competition will limit other species of mammals, birds (excluding waterfowl) and reptiles. Each species will decline in population, but the degree of loss will depend upon mobility, new habitat suitability, existing population densities and level of predation in the new habitat. Approximately 250 species of birds will have their habitat eliminated or altered in the flooded section [Highlands Audubon Society]. The ultimate decrease in the deer population will lead to subsequent loss of approximately 1,800 man-days of hunting each year. Other game hunting losses will total 750 man-days annually. An additional 1,800 man-days per year of other wildlife-oriented recreation will also be forfeited.

Movement to new habitat areas will be further restricted by roads. The project area is bounded by Routes I-80 and I-78 on the south, I-84 on the north, Route 209 on the west and Route 94 on the east. Certainly, many terrestrial animals will be killed or injured in their attempts to cross these thoroughfares. Others will be deterred from crossing, thereby preventing dispersion to a new habitat area.

Rare and endangered animals which reside in or frequent the project area include the New England cottontail, snowshoe hare, eastern woodrat, porcupine, black beaver, river otter, Kenn's bat and Leeb bat. The black tern, arctic peregrine, least bittern, barred owl, short-eared owl and king rail are among those rare or threatened avian species which might suffer loss of nesting and feeding habitat due to brush clearing and dam construction. At worst, regional extinction of any of these species may occur. Salamanders are probably the most vulnerable of the amphibians.

The copperhead snake and bog turtle (considered by many to be dying species) may be regionally lost because their preferred habitat is primarily in the low-lying areas that will be cleared.

These construction impacts may be lessened by a gradual clearing of the area, allowing displaced animals to relocate and establish new territories, if possible. There is no feasible means of preventing substantial loss of wildlife if the reservoir is constructed.

X.A.5 CONSTRUCTION IMPACTS UPON WATER QUALITY

Impacts on water quality during the construction phase will result from riverbed and land disturbances. Dredging, excavation, roadbuilding, and vegetation removal are some of the operations effects which will be examined.

The first operation during construction will be the dredging of the existing Delaware River channel at the dam site for the later placement of select material to act as a shear key. A hydraulic dredge will be used to remove the sediment material (these dredges cause significantly less disturbance than mechanical dredges) and to deposit the dredged slurry into holding ponds upstream from the dam site. Water from these holding ponds will be discharged into the river after sedimentation.

The degree of turbidity will depend upon the care taken to observe proper operating procedures. According to the Civil Works Construction Guide for Environment Protection of the Corps of Engineers, increases in stream turbidity must be monitored throughout the construction operation to meet applicable water quality objectives. Unfortunately, no water quality objectives for turbidity in this reach of the Delaware have been adopted by the DRBC. It is to be hoped that some acceptable degredation limits can be established so that monitoring can be effectively used to identify offending practices.

Significant erosion and resulting stream siltation will occur during the

earthwork operations. Monitoring and the resulting abatement operations will at best only limit the duration of stream degradation.

Diversion of the river through a temporary channel on the Pennsylvania side will contribute to increased siltation. Once again, the extent of expected erosion would be small if the channel is properly designed to pass floodwater without excessive velocities. The impact of increased suspended sediment under floodwater would be small as the Delaware carries a substantial suspended sediment concentration at high flow rates.

Precipitation will cause erosion from excavation sites and roads. The impact of such erosion would depend upon ambient stream turbidity (which depends upon stream flow and the storm severity).

Vegetation clearing will be designed to minimize erosion. The clearing process is expected to proceed sequentially with reservoir filling, thus reducing the amount of disturbed land exposed. According to Design Memorandum No. 14 for the Blue Marsh Lake Project, which will be essentially followed in this project, trees and shrubs will be cut down within six inches of the ground. Their roots and other low-lying vegetation will be preserved to maintain the capacity of the land to intercept and store rainfall and to dissipate the energy of rain. Sedimentation basins, to be located at appropriate drainage concentrations, will trap sediment and reduce stream turbidity.

If experience is a guide, substantial erosion will occur. Only if a

turbidity monitoring and control program is operated, both above and below the dam site, can the duration of turbidity increases be minimized and ambient water quality be maintained.

Possible water quality degradation from spilled chemicals, fuels, oils, greases, bituminous materials, waste washings, herbicides and insecticides and discharge of washing and curing water can be substantially minimized if proper procedures are followed. However, a limited number of spills and accidental discharges will probably occur and result in some water quality degradation. These should not be substantial, and strict requirements to prevent them should be incorporated into construction specifications.

The following proposed measures to reduce or prevent the intrusion of mud and loose sediments into on-site, or nearby, waterways are noted: 1) Design Memorandum No. 8 (pg. 7-1) discusses the allocation of over $500,000 for rip rapping temporary ditches, temporary berms along the edges of shoulders to prevent erosion of the embankment until the ground cover takes over, and temporary settling ponds for runoff during construction of highway work for the project. Similar measures would be applicable to control this problem during construction of the dam, during stripping operations and during other phases of construction: 2) Supplement No. 1 to Design Memorandum 9 (pg. 10) discusses sedimentation testing which was performed on samples of material expected to be dredged from the bottom of the river in order to form the shear keys and cut off. The tests indicated that for the proposed configuration of the dredge

spoil area, the effluent discharged into the river would not have excessive turbidity. The possible addition of flocculants to further reduce the solids in the effluent is discussed: 3) Conformance with the Pennsylvania Clean Stream Law and with DOT, USDA Soil Conservation Service, and COE requirements and guidelines will also be effective.

Significant mitigation measures are being proposed to reduce the amount of erosion and resulting degradation of stream quality that is bound to occur. To the extent that these precautions are effect'ive, such water quality degradation should be reduced. Adequate monitoring can be installed to insure that violations are not repeated. In general, the adverse impacts will be mainly short-term and not long-term.

X.A.6 CONSTRUCTION IMPACTS UPON HISTORICAL AND ARCHAEOLOGICAL SITES

Earth moving operations during construction will have a very adverse effect on archaeological sites in the area of the project. Construction of the dam will require large scale excavation and earth moving by heavy equipment. These operations will disturb the soil to a depth of at least five or six feet thereby destroying the archaeological records.

One of the most dependable methods of classifying artifacts as belonging to a particular period is by their association with identical stratigraphic levels. Random disturbance of the soil column renders categorization of artifacts to a particular period impossible.

Artifacts found at the same stratigraphic level can be studied to yield a total composite picture of the tools of the aboriginal inhabitants of the site. Clues as to vegetal resources available to prehistoric populations can be revealed by pollen analysis within the same stratigraphic level. These insights yield researchers an understanding of the diets of the prehistoric people and possible resources they could have exploited for household and life-support purposes. Within the assumption that valuable archaeological sites exist in the area of construction, irreversible impacts may occur when artifacts are unearthed randomly out of context with artifacts of other periods.

The purpose of archaeological explorations is to inform researchers of the

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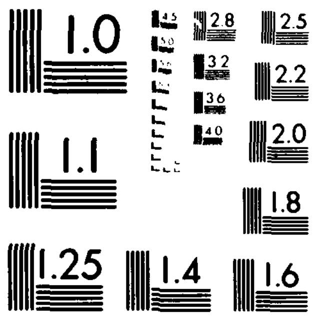

MICROCOPY RESOLUTION TEST CHART
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aboriginal adaptations, thereby increasing the understanding of the cultural evolutionary sequence. Information pertaining to the Delaware River Valley is not restricted in value to the local prehistory. Such information is valuable in understanding the Delaware Basin prehistoric native adaptations and in contributing to the understanding of successful aboriginal adaptation on a continental scale.

Radiocarbon dating of non-organic artifacts is severely hampered when the surrounding soils are disturbed by construction operations. The carbon-14 dating method involves relating to the date of a piece of charcoal found in the same stratigraphic layer as the non-organic artifact. Movement of soil will destroy the stratigraphic interpretation of numerous artifacts regarding riverine adaptation along the Delaware River. Thus, substantial information may be lost regarding prehistoric life-styles, including cooking methods, tool manufacturing and construction of hearths and pits.

In the construction phase of the Tocks Island dam it will be necessary to clear underbrush with heavy machinery. Lightly forested areas of underbrush usually mean that the soil there has lain relatively undisturbed for years. Excavations in these areas, if productive, would probably yield period artifacts at contiguous levels. However, clearing underbrush in an area that is productive archaeologically may also randomly unearth artifacts. With the introduction of heavy machinery and turning of the soil, any potsherds and artifacts which are recovered may be broken in the process of earth moving.

Artifacts which are not salvaged will be exposed and left to further destruction by air, rain, extreme temperatures, snow and oxidation.

The use of borrow pits in the construction of the dam and reservoir will be another facet of soil disturbance which may contribute to adverse archaeological impacts. The borrow pits may be located within the area of inundation or in surrounding areas having easy access for earth moving equipment. Thus, the disturbance of archaeological sites may range outside of the area of inundation due to the demands of reservoir construction.

Material which is used as fill in another area will be useless to archeologists for determining the exact location of prehistoric occupations. In fact, it would be extremely unwise to try to reconstruct what aboriginal life looked like from archeological remains found in a landfill. The chemical composition of the soil at a particular stratigraphic level is very important to the preservation of the artifact. By analyzing the acidity and corrosive character of the soil, investigators can discern how well preserved the artifactural material is, or if any decomposition of the artifactural material has occurred. The acidity in the soil at particular stratigraphic levels can reveal information concerning preservation of human or animal bone material. Therefore, it is useful to analyze the chemical composition of excavated sites.

In conjunction with EPA standards, subcontractors who use water in construction, or create wastewater, must chemically adjust the wastewater to match

the pH [acidity] level of the regular water source. The chemical adjustment of the water may allow certain chemicals to leach into the soil, changing the chemical composition of the soil. Changes in the composition of the soil could be misleading in a stratigraphic analysis of the chemical composition of the soil and its effects on material culture remnants.

Archeological excavations in the DWGNRA have produced artifacts of the Historical and Contact periods. It is from those later artifactual finds that we can ascertain information about contact between the late Woodland Indians of the area and the European settlers. Many of the artifacts from the Historic periods indicate that trade networks were set up between the Indians and the Europeans. Artifacts such as glass beads, glass bottles bearing the coat of arms of an English family, and copper vessels have been excavated. These artifacts were not very deep under the topsoil, and can be dated to the 17th and 18th century. Often artifacts of the Contact-Historic period will be found in association with the sites of Indian encampments. It is from the discovery of these Historic period artifacts, as well as the fact that the Europeans began to record their travels and exploits in the area, that we know that Woodland Indians and Europeans coexisted in the Delaware River Valley.

After identification of an archaeological site during the construction phase of the Tocks Island dam, a competent archaeological excavation is required. A construction superintendent may not be able to identify a meaningful archaeological site and, furthermore, it is doubtful that if

identified, adequate time and funding could be allocated for proper excavation. Even if removal of artifacts could be facilitated during construction, these would be remnants of material culture not identified in situ and thus out of context, thereby yielding little positive information toward accurate reconstruction of our past.

The Delaware River Valley area is an area of historic importance. Farm complexes composed of houses, outbuildings and structures designed for agricultural use, such as corn cribs and troughs, are present in the area. Mills and buildings related to the early forms of manufacturing in the area remain. The Delaware River contributes a great deal to the history of transportation as well, with its ferry crossings, inns and bridges throughout the area.

Historic surveys of the area have resulted in the identification of many buildings of historic importance located in the floodplain area of the Tocks Island reservoir. Criteria such as architectural uniqueness and historic associations have been employed in order to evaluate the significance of the structures located in the pool area of the dam. In this area many of the homes have been recommended for preservation.

Construction impacts on those sites not chosen for relocation will be absolute. Houses and structures in the reservoir will be leveled for shaping the reservoir bottom. After a survey of the area, however, a number of historic structures have been recommended for relocation. Relocation in itself, however, poses the danger of destruction or partial destruction of

the structure due to age, size and building composition.

There exists a great danger of thefts of historical artifacts during the construction phase. Construction personnel may strip the historic buildings of salvageable goods, for private ends. An additional danger is present during the brush clearing operation. The threat of fire from emission sparks becomes highly probable. Uncontrolled fire could destroy some of the historic structures scheduled for preservation.

Construction impacts to historical archaeology are much the same as those impacts on prehistorical archaeology. Excavation of those artifacts which yield information about early colonial times are in danger of being unearthed without the proper classification in an historical context. Cemeteries which exist in the area may be uncovered by heavy machinery during dam construction. However, cemeteries and the remains therein are often recommended for relocation, especially to preserve the headstones. If relocation is done, it must be done very carefully, counting each grave and accurately recording its contents.

The severest loss to historical structures in the floodplain area through construction will be at the actual site. Many of the structures in the area derive their unique historical significance from their location. Resort homes and inns, such as Van Campen's Inn, were located on roads used as early as the colonial period. It is precisely their locations along these historic routes which makes such structures significant. Preservation by relocation looks only to the architectural preservation of

the structure. Thus, even with the admittedly good approach being taken to save these structures, the sense of their historically significant settings will be lost if they are relocated.

Sections of the Old Mine Road are located within the reservoir area. The road is one of the oldest routes of any length in the East. Sections of the road extending outside of the pool area can be preserved. The Pahaquarry Copper Mines are also in danger of partial inundation. The mines were worked by Dutch colonists and their history contributes to the knowledge of early methods of production in the valley. Mitigating measures are expected to be taken for the mines and the Old Mine Road, preserving and making them accessible to the public for those portions not innundated.

The Delaware River Basin has been the scene of many skirmishes between native Americans and European colonial settlers. There are fort sites and battlefields reported throughout the area. Foundation structures are all that remain of many of the forts. Battlefields adjoining these forts are historically significant by their location in the valley and will be lost if the dam is built.

There are some complete towns that date to early colonial settlement periods in the Delaware River Valley. The sites of such towns as Bushkill, Dingman's Ferry and Flatbrook will be lost through inundation. Suggestions have been made to relocate the entire towns and restore them to the style of the early period in which they were founded.

Construction impact on the historical resources of the area is largely the demolition of houses and other historical structures which are not recommended for preservation. The social effect of demolition of these houses is that many people who have made their homes, and second homes there, will be forced to relocate. The potential for vandalism to the structures, as well as to the grave sites and historical archaeological remnants is great.

Those historical structures not recommended for preservation will be carefully inventoried, measured and photographed. The National Park Service intends to restore and maintain all historical structures in the park area that are slated for preservation. A full statistical breakdown of structures to be preserved on site, relocated or innundated is found in Chapter XXII.

X.A.7 NOISE POLLUTION

Construction air and noise impacts are considered short-term environmental effects. The noise of machinery and workmen will temporarily disturb the terrestrial biota of the surrounding area. However, the physical presence of humans in the area will cause the animals that can flee to migrate.

Noise restriction requirements should be included in the construction contract guided by the provisions of the Walsh-Healy Act. On-the-job enforcement of these requirements is essential. The Walsh-Healy Act was designed to protect workers, but of course, has a salutary effect in reducing noise levels in the general environs.

X.A.8 AIR POLLUTION

Air pollution in the forms of dust and exhaust emissions from equipment also will be an unavoidable consequence of the proposed project during the construction stage. Control of pollution levels involves:

1. Dust control measures to be part of the contractual obligations of the construction contractors.
2. Emission control standards legislated by the Congress under OSHA to be enforced.
3. Open air burning to be restricted in accordance with local, state and federal regulations.

4. On-site production of aggregates, if necessary, to be required to meet air quality regulations in force at the time of construction.

X.A.9 SOURCE OF FILL FOR THE PROJECT

Questions have been raised as to the source of the fill for the proposed dam. The proposed borrow areas are shown on Plate 19 of Design Memorandum No. 6. For impervious material, two sources are available upstream of the dam. For transition zone and filter material, sources are available on Depue and Tocks Islands. The required rock fill is expected to come from spillway excavation in the left abutment of the dam.

X.B. WATER ALLOCATIONS AND PRIORITIES

The major responsibilities relative to water allocations and priorities in the Delaware River Basin rest with the Corps of Engineers and the Delaware River Basin Commission. The Corps of Engineers, primarily a planning, design and construction agency, performs its work on a basin-wide basis so as to maximize net economic benefits to the basin. The Delaware River Basin Commission, formed about the time of the completion of the comprehensive report of the Corps of Engineers, is responsible for ongoing planning and implementation of water resources development projects in the basin.

The explicit water allocation strategy of the DRBC is based on the Compact which formed the Commission. A major emphasis in the compact is the allocation of water to member states. Until recently the DRBC has been implementing water resources projects as needed to meet the water demands of all users. Except during periods of drought, there has not been much difficulty in meeting water demands as there has been adequate water for all users. During the drought of the 1960's water was allocated to municipal and industrial users at the expense of the generation of hydroelectric power, thus implicitly assuming that hydro-electric power was of less value to the community than water supply.

Recent papers of the DRBC staff ("Interrelationships of Water Resources Policy Issues and Planning Assumptions," Jan. 16, 1975 and "Salinity Control Flow Policy Issue", Jan. 21, 1975) have discussed water resources of the basin through six major policy issues: salinity control flows; drought/flood

frequency protection; water supply requirements; priority of water uses; exportation and importation; and legal considerations. The development of these policy issues and associated alternative planning assumptions is by no means concluded and no decision has been reached as to final planning assumptions or guidelines.

In recent years it has become apparent to the DRBC that it may be necessary to limit the growth of water use in the basin. This is because the water resources of the basin are limited and would be ultimately exhausted if increased consumptive use continues unchecked. The potential consumption for cooling requirements of the electric power industry in particular has been investigated by the DRBC. A policy regarding consumptive use, that users must provide their own storage or pay for the water they use, is presently being implemented.

Even if Tocks Island reservoir and other projects in the DRBC comprehensive plan are constructed, limitations will ultimately have to be placed on consumption in the basin. If the Tocks Island Lake Project is not completed, it will be necessary to put a use control program into effect even sooner.

X.C. COMPATIBILITY WITH AUTHORIZED PURPOSES

The Tocks Island Lake Project was authorized by the Flood Control Act of 1962 (P.L. 87-874) to be constructed in accordance with the Corps of Engineers Delaware River Basin Report (House Document 522, 87th Congress, 2nd Session).

The authorized purposes include control of flood flows, control of low flows for water supply purposes, enhancement of recreation opportunities, and construction of conventional hydroelectric power supply facilities. Section 5 of P.L. 91-283 modified the Tocks Island Lake Project to permit the power generation aspect to be developed by specified private utilities as an antecedent to their proposed pumped storage development at Tocks Island and Kittatinny Mountain. Additionally, recommendations were made by the Board of Engineers for Rivers and Harbors that studies be made to determine the value of water storage for improvement of the quality of water.

X.C.1. FLOOD CONTROL

There have been 12 significant floods in the Delaware River Basin in the past 130 years. The Tocks Island reservoir would eliminate downstream damages such as those caused by these occurrences, i.e., by all storms of record. Annual benefits to be derived amount to more than $2,190,000 (DM-#3 pg X-1, July 1969). It is noted, however, that the Tocks Island

Lake Project, as currently envisioned, does not provide flood protection for reaches above the reservoir, on tributaries, or in the lower regions of the river.

X.C.2. WATER SUPPLY

Approximately 60 percent of current surface and groundwater needs in the Delaware River Basin occur in the Philadelphia-Trenton area. Sufficient flows are currently available to meet these needs. By the year 2010, however, the needs of the Philadelphia-Trenton area alone will require 1356 MGD (Ref. DM 3 #1 pg C-7) more than the current supply. Of this amount, it is intended that 730 MGD would be available from the TILP. In addition, although primary water needs lie within the basin, the needs of the large metropolitan areas outside the basin have impelled these areas to request the diversion of water from the basin to supply their projected needs. The Supreme Court Decree of 1954 authorizes such diversions in accordance with terms and conditions specified therein.

Benefit to be realized from the water supply aspect of the proposed project is the provision of the above noted additional water supply equivalent to an average annual benefit (based on comparison to the least costly alternative) of $6,801,000 (DM-#3 pg X-1, July 1969).

X.C.3. RECREATION

The National Park Service (NPS) has developed a Master Plan for the com-

bined Delaware Water Gap National Recreation Area (DWGNRA) and the Tocks Island reservoir. The DWGNRA was authorized by P.L. 89-158, 89th Congress. The Master Plan describing 31 directly related recreation sites within the combined area was approved by the Washington Office of NPS, although never formally approved by the Corps of Engineers. Based on coordination meetings with the Bureau of Outdoor Recreation, the National Park Service and the Corps of Engineers, the following conclusions were reached:

a. Combined ultimate capacity of DWGNRA and TILP recreation areas could be 10.5 million visitors annually.

b. Potential market demand far exceeds the planned resource capacity of DWGNRA.

Recreational amenities to be developed include the following facilities: observation and sightseeing, boat launching, picnic, camping, swimming and bathing, fishing, roads, trails and causeways, boat docking and beaching, turfing and landscape planning, safety and public health, maintenance and service, and concessions.

The annual benefits to be derived are estimated to be $12,671,000 based on $1.35/yr/visitor with a net visitation of ten million annually.

X.C.4. FISH AND WILDLIFE

X.C.4(a) Wildlife

The site for the Tocks Island Lake Project supports a variety of wildlife. The main game animals include deer, rabbit and raccoon and the main game

birds include grouse, pheasant, woodcock and waterfowl. Approximately 10,000 acres of land will have to be inundated in order to create the 12,500 acre reservoir. Wildlife will be adversely affected when portions of an additional 6,000 adjoining acres are periodically inundated during flood control operations. Intangible losses include the losses due to inundation of bottom lands, a critical food source for deer. Tangible losses include hunter-day losses amounting to $698,000 (pg III-17 DM-#3 or 6-4 DM-#3 Supp. #1).

X.C.4(b) Fisheries

Currently, 46 species of fish exist in the Delaware River Basin. Those of importance to sport fisheries include: shad, brook trout, brown trout, rainbow trout, rock bass, sunfish, blugill, largemouth and smallmouth bass, black crappie, yellow perch and walleyed pike. The most important game fish are smallmouth bass and walleyed pike. The annual effect on sport fishing by the reservoir will be a net gain above the reservoir site, no gain at the reservoir site, and a net loss downstream of the site, resulting in a net gain of 247,000 man-days valued at $371,000. Sport fishing for shad results in a net loss in all areas valued at 80,000 man-days, or $400,000. Commercial fishing industry includes oysters, shad an eel. All three industries will suffer a net loss of $714,000. To offset these losses it is planned to construct sport fishing facilities including tailwater fishing, fishing piers, fish concentrations and scenic areas valued at $255,000. All the aforementioned, when taken together, result in a net loss of $488,000 due to the construction of the reservoir.

The U.S. Fish and Wildlife Service, in cooperation with the state fishing agencies involved, recommend in addition to the above-mentioned fishing facilities: fish passage facilities, zoning of the lake, maintenance of downstream releases within 8°F of inflow temperatures, and release of all flows except flood flows from April through June to inhibit oyster drill infestation at Delaware Bay. Provisions for passage of anadromous and catadromous species to spawning and nursing areas will be maintained during and after construction. Stream sediment loads and turbidity will be limited during construction.

X.C.5. POWER SUPPLY

A conventional hydroelectric power facility is to be developed at the Tocks Island reservoir site. This development was found to be feasible and a market for power is readily available. The facility is rated at 70 Mw with a dependable capacity of 38 Mw. Average annual energy is expected to be 307 million kw-hours. The benefit of power produced was determined by the Federal Power Commission to amount to $2,170,000.

A pumped power storage facility developed at Tocks Island reservoir would use the reservoir as its water source and lower reservoir. Rated capacity would be 1250 Mx. (figures from Appendix G DM 3 supp't).

X.C.6. COMPATIBILITY WITH POLICIES OF THE AREA, REGION AND NATION

Formal county planning documents do not reveal any official conflicts. Local governmental officials have expressed concern about road, police and public services to meet projected demand; the fact that year-round employment will not be favorably affected due to the seasonal nature of the project and because contractors may bring in their own work force; and, overall damage to the rural atmosphere.

The States of New Jersey, New York and Pennsylvania have no official land use plans, policies or positions which are in conflict with the Tocks Island Lake Project.

Federal standards applicable to the Tocks Island Lake Project include:

1. U.S. Water Pollution Amendments - Tocks Island conforms to requirements for salinity levels downstream and will sustain developments away from the project area.
2. Clean Air Act - Automobile pollutants will increase but local dispersions characteristics are good due to the large amount of open space and vegetation.

X.C.7 COMPATIBILITY EVALUATION

Based upon the review of authorizing legislation and regulations and upon the proposed preliminary designs and proposals for the Tocks Island Lake Project and the Delaware Water Gap National Recreation Area outlined previously, the Project and the Recreation Area are compatible with their authorized purposes.

X.D. SUMMARY PROFILE OF T.I.L. AREA

The Tocks Island Lake Area is defined to include the following seven counties: Warren and Sussex counties in New Jersey; Orange and Sullivan counties in New York; and Monroe, Northampton and Pike counties in Pennsylvania. The seven-county area as defined is considered the primary impact area.

From the time of early settlement through to the present, the physical and the environmental attributes have been the dominant force in the development of the area's economy. The early settlements were in response to the region's natural resources such as lumber and minerals. Accessibility brought on by completion of the interstate highway system over the years, however, has had a dramatic affect on what was a stable rural economy. New industries have sought a location within the seven-county area while improved accessibility has brought on substantial growth in tourist activity and tourist serving commercial and service jobs. In addition, urban sprawl from the New York-New Jersey metropolitan areas has added further population pressures in the seven-country area.

X.D.1 POPULATION AND DEMOGRAPHY

The population of the seven-county Tocks Island Lake Impact Area increased from 591,618 in 1960 to 736,800 in 1973; a gain of 145,182 people or a population increase of 24.5 percent over the 13-year period between 1960 and 1973. During the same period, the population of the larger Delaware

River influence area (defined to include 52 counties in the four-state area) increased by 12.2 percent or by 2,840,261 people. As shown in the following table the rate of population growth in the seven-county impact area far exceeded the rate of population growth of the larger Delaware River influence area over the 1960-70 and 1970-73 periods. Over the 1960-70 period, the seven-county area accounted for 3.9 percent of total population gains in the larger influence area. However, over the three-year period between 1970 and 1973, some 28.8 percent of the population growth occurring in the larger influence area occurred in the seven-county area.

Table 10 - 1 Population Trends, Tocks Island Lake Impact Area and Delaware River Influence Area, 1960-1973

	1960	1970	1973	Gain, 1960-70 Amount	Gain, 1960-70 Percent	Gain, 1970-73 Amount	Gain, 1970-73 Percent
Warren	63,220	73,960	76,400	10,740	17.0%	2,440	3.3%
Sussex	49,255	77,528	85,600	28,273	57.4%	8,072	10.4%
Orange	183,734	221,657	233,600	37,923	20.6%	11,943	5.4%
Sullivan	45,272	52,801	57,700	7,529	16.6%	4,899	9.3%
Monroe	39,567	45,422	49,300	5,855	14.8%	3,878	8.5%
Northampton	201,412	214,545	221,300	13,133	6.5%	6,755	3.1%
Pike	9,158	11,818	12,900	2,600	29.0%	1,082	9.2%
Total, T.I.L. Impact Area	591,618	697,510	736,800	105,892	17.9%	39,290	5.6%
Delaware River Influence Area	23,059,139	25,762,898	25,899,400	2,703,759	11.7%	136,502	0.5%

Sources: U.S. Census of Population, 1960 and 1970, CPR P-25 and 26.

The seven-county impact area contains a diverse mixture of counties ranging from medium-sized Orange and Northampton counties with over 200,000 residents to relatively sparsely populated Pike County with only 12,900 residents in 1973. The population, however, is evenly balanced between urban and rural residents. Just over 50 percent of the population was considered urban by the Bureau of Census in both 1960 and 1970. Despite the suburbanizing trends in Orange and Sussex counties, population growth was evenly split between urban and rural sectors. The rural population declined in only two counties, Northampton (Allentown and Bethlehem) and Warren counties. Sullivan, Monroe and Pike counties maintained mostly rural population as seen in the following table.

Table 10 - 2 Urban/Rural Distribution of Population, Tocks Island Lake Impact Area, 1960 and 1970

	Urban		Rural		Percent Urban	
	1960	1970	1960	1970	1960	1970
Sussex	18,225	29,887	31,030	47,641	37.0%	38.5%
Warren	32,137	43,338	31,083	30,622	50.8%	58.6%
Orange	93,139	113,317	90,595	108,340	50.7%	51.1%
Sullivan	9,926	10,284	35,346	42,296	21.9%	19.6%
Monroe	13,744	13,345	25,823	32,077	34.7%	29.4%
Northampton	138,341	153,583	63,071	60,216	68.7%	71.8%
Pike	-	-	9,158	11,818	0%	0%
Total, T.I.L. Impact Area	305,512	363,754	286,106	333,010	51.6%	52.2%

Source: U.S. Census of Population, 1960 and 1970.

In 1970, 52.2 percent of the T.I.L. Impact Area's population was living in rural areas. This represented only a slight change from a 51.6 percent urban share in 1960. Three counties had more urban than rural residents including Northampton, Orange and Warren counties in 1970. The others had a greater proportion of rural residents with Pike County being considered 100 percent rural.

In 1973, the impact area had 230,250 households, an average of 3.2 persons living in each occupied housing unit. As a result of declining birth rates in recent years resulting in a general trend towards smaller households, the number of households increased at a faster rate than the rate of growth of population over the 1960-73 period. The number of households increased by 29.6 percent over the 1960-73 period compared to a 24.5 percent gain in population over the same period.

The number of households increased from 177,652 in 1960 to a 1973 total of 230,250 in the T.I.L. Impact Area generally reflecting population change by county. However, the average number of persons living in each household declined from 3.33 in 1960 to 3.20 in 1970 resulting in a slightly more rapid household growth rate.

Table 10-3 Household Trends, Tocks Island Lake Impact Area and Delaware River Influence Area, 1960-1973

	1960	1970	1973	Gain, 1960-70		Gain, 1970-73	
				Amount	Percent	Amount	Percent
Warren	19,233	23,271	24,269	4,038	21.0%	998	4.3%
Sussex	14,434	22,809	25,176	8,375	58.0%	2,367	10.4%
Orange	53,919	65,607	69,297	11,688	21.7%	3,690	5.6%
Sullivan	14,112	16,934	18,655	2,822	20.0%	1,721	10.2%
Monroe	12,112	14,674	16,175	2,562	21.2%	1,501	10.2%
Northampton	60,712	68,632	72,038	7,863	13.0%	3,406	5.0%
Pike	3,130	4,130	4,544	1,000	42.0%	414	10.0%
Total, T.I.L. Impact Area	177,652	215,988	230,250	38,336	21.6%	14,262	6.6%
Delaware River Influence Area	7,124,885	8,280,375	8,435,424	1,155,490	16.2%	155,049	1.9%

Sources: U.S. Census of Population, 1960 and 1970, Current Population Reports, P.25 and P-26.

As seen in the following table, total personal income in the seven-county impact area increased from $1,249,000,000 in 1959 to $3,181,000,000 in 1972, a gain of $1,932,000,000 or 154.7 percent over the period.

Table 10 - 4 Total Personal Income Trends, T.I.L. Impact Area and Delaware River Influence Area, 1959-1972
(In millions of current dollars)

	1959	1969	1972	Change, 1959-69 Amount	Change, 1959-69 Percent	Change, 1969-72 Amount	Change, 1969-72 Percent
Warren	$ 129	$ 262	$ 337	$ 133	103.1%	$ 75	28.6%
Sussex	98	245	333	147	150.0%	88	35.9%
Orange	400	820	1,065	420	105.0%	245	29.9%
Sullivan	101	187	229	86	85.1%	42	22.5%
Monroe	76	150	186	74	97.4%	36	24.0%
Northampton	430	776	978	346	80.5%	202	26.0%
Pike	15	38	53	23	153.3%	15	39.5%
Total, T.I.L. Impact Area	$ 1,249	$ 2,478	$ 3,181	$ 1,229	98.4%	$ 703	28.4%
Delaware River Influence Area	$62,305	$116,094	$141,146	$53,789	86.3%	$25,052	21.6%

Sources: U.S. Department of Commerce, Survey of Current Business (May, 1974).

As shown in the above table, the largest dollar gain in personal income over the 1959-72 period occurred in Orange County while Pike and Sussex counties had the fastest rate of total personal income growth over the 1959-72 period.

Eliminating inflation-caused increases by using constant 1972 dollars, real personal income in the seven-county impact area increased by $1,389

million, a real gain in income of 77.5 percent over the 1959-72 period. The real gain in total per capita income amounted to $1,288 or 42.5 percent over the 1959-72 period. These income trends are shown below.

Table 10 - 5 Comparison of Total Personal Income in Constant and Current Dollars, Tocks Island Lake Impact Area, 1959-1972

	Millions of Current Dollars	Millions of Constant 1972 Dollars	Constant Dollars Per Capita Income
1959	$1,249	$1,792	$3,029
1969	$2,478	$2,827	$4,053
1972	$3,181	$3,181	$4,317
Gain, 1959-72			
Dollars	$1,932	$1,389	$1,288
Percent	154.7%	77.5%	42.5%

Sources: U.S. Department of Commerce: Survey of Current Business (May, 1974).

X.D.2 THE ECONOMY

The structure of the seven-county impact area economy can be described and characterized as: (1) predominantly oriented to and dependent upon the recreation and tourist-related activities, and (2) dependent upon manufacturing and processing activities. The individual county economies making up the total impact area vary from predominantly oriented to and dependent upon manufacturing activity as a source of jobs and income (Northampton and Warren counties) to heavily service-based economies of Pike, Sullivan and Sussex counties. The economy of Orange and Monroe

counties represent a relatively balanced mixture between the manufacturing and non-manufacturing activities.

Generally, the Tocks Island Impact Area has experienced steady economic growth as reflected in its employment gains. Over 50,000 new jobs were added to the impact area during the 1960-1972 period. Orange County had the largest numerical gain in jobs with Sussex and Warren counties also having sizable employment gains as shown in the following table.

Table 10 - 6 Employment Trends (Nonagricultural Wage and Salary Workers), Tocks Island Lake Impact Area and Delaware River Influence Area, 1960-1972 (thousands)

	1960	1970	1972	Gain, 1960-70 Amount	Gain, 1960-70 Percent	Gain, 1970-72 Amount	Gain, 1970-72 Percent
Warren	19.6	25.3	26.3	9.2	46.9%	1.0	4.0%
Sussex	9.5	16.8	19.6	7.3	76.8%	2.8	16.7%
Orange	53.0	70.0	69.2	17.0	32.1%	- 0.8	- 1.1%
Sullivan	20.8	22.2	22.9	1.4	6.7%	0.7	3.2%
Northampton	78.2	90.0	87.5	11.8	15.1%	- 2.5	- 2.8%
Monroe	14.8	20.3	22.9	5.5	37.2%	2.6	12.8%
Pike	1.8	2.6	2.9	0.8	44.4%	0.3	11.5%
Total, I.I.L. Impact Area	197.7	247.2	251.3	49.5	25.0%	4.1	1.7%
Delaware River Influence Area	8,495.5	10,068.3	9,979.5	1,572.8	18.0%	-88.8	- 0.9%

Note: Nonagricultural wage and salary workers excludes the self-employed, nonpaid family worker, private household workers and military personnel.

Sources: New York Department of Labor: Employment Review, Pennsylvania Department of Labor and Industry, New Jersey Department of Labor and Industry, U.S. Census of Population, 1960 and 1970.

Overall, the Tocks Island Lake Impact Area had 251,300 nonagricultural wage and salary jobs in 1972 compared to 197,700 in 1960. The largest employment concentrations are found in Northampton and Orange counties, which between them contain over 60 percent of at-place employment in the T.I.L. Impact Area. The economy of the impact area grew more rapidly than the influence area's with a 25 percent gain in employment compared to an 18.0 percent increase for the broader region between 1960 and 1970. During the 1970-1973 period, the T.I.L. Impact Area added 4,100 jobs while the Delaware River Influence Area actually lost jobs.

The seven-county impact area economy taken as a whole contains proportionately more manufacturing jobs (33.3 percent) compared to the share of total employment in manufacturing (26.0 percent) in the United States. However, this belies the service oriented nature of a large part of the seven-county impact area.

Table 10 - 7 Manufacturing and Nonmanufacturing Employment Trends, Tocks Island Lake Impact Area, 1962-1972
(Thousands of Workers)

	1962	1972	Gain, 1962-72 Amount	Gain, 1962-72 Percent
Manufacturing	78.2	83.7	5.5	7.0%
Nonmanufacturing	123.8	167.6	43.8	35.4
Total	202.0	251.3	49.3	24.4%
Percent of Total:				
Manufacturing	38.7%	33.3%	11.2%	
Nonmanufacturing	61.3	66.7	88.8	
Total	100.0%	100.0%	100.0%	

Sources: New Jersey and Pennsylvania Departments of Labor and Industry, New York Department of Labor: Employment Review, U.S. Department of Commerce: County Business Patterns, 1962 and 1972.

As shown in the above table, manufacturing employment in the impact area increased by 5,500 while 43,800 nonmanufacturing jobs were added to the economy during the period between 1962 and 1972. Consequently, while the percentage of manufacturing jobs remained high compared to national averages, primary growth occurred in the nonmanufacturing portion.

The breakdown of employment into manufacturing and nonmanufacturing sectors by county provides a clearer picture of the diversity of individual county economies within the seven-county impact area. As shown in the following table, a relatively large proportion of total employment in Northampton and Warren counties is concentrated in the manufacturing

Table 10 - 8 Manufacturing/Nonmanufacturing Sector Employment Trends By County, Tocks Island Lake Impact Area, 1962-1972 (thousands)

	1962		1972		Nonmanufacturing, Percent of Total	
	Manufacturing	Non-Manufacturing	Manufacturing	Non-Manufacturing	1962	1972
Warren	10.6	9.1	12.1	14.2	46.2%	54.0%
Sussex	2.4	8.3	2.5	17.1	77.6%	87.2%
Orange	15.8	39.1	14.8	54.4	71.2%	78.6%
Sullivan	0.5	19.9	0.6	22.3	97.6%	97.4%
Northampton	44.4	33.8	48.7	38.8	43.2%	44.3%
Monroe	4.4	11.5	4.9	18.0	72.3%	78.6%
Pike	0.1	2.1	0.1	2.8	95.5	96.6%
Total, T.I.L. Impact Area	78.2	123.8	83.7	167.6	61.3%	66.7%

Sources: New Jersey and Pennsylvania Departments of Labor and Industry, New York Department of Labor: Employment Review, U.S. Department of Commerce: County Business Patterns, 1962 and 1972.

sector while employment in Pike, Sullivan and Sussex counties is concentrated in the trade and services activities reflecting the tourist and recreation related nature of their economies.

Although each of the counties in the T.I.L. Impact Area showed a general trend toward a higher proportion of nonmanufacturing employment, broad variations among them remained in 1972. Only 44.3 percent of Northampton County jobs were in nonmanufacturing industries compared to over 96 percent in Pike and Sullivan counties.

In 1972, nearly 45 percent of total manufacturing employment in the impact area was concentrated in two industries -- primary metals and apparel. Major water-using industries, food, textiles, pulp and paper, chemicals, leather and primary metals, accounted for 47.2 percent of the total manufacturing employment in 1972. Detailed manufacturing employment trends for the seven-county impact area as a whole are shown in the following table.

Table 10 - 9 Manufacturing Employment Trends by Two-Digit SIC Code Industry, Tocks Island Lake Impact Area, 1962-1972 (thousands)

			Gain, 1962-72		Percent of Total	
			Amount	Percent	1962	1972
Food	3.9	4.1	0.2	5.1%	5.0%	4.9%
Textiles	5.1	5.1	0.0	0.0%	6.5	6.1
Paper	2.2	3.6	1.4	63.6%	2.8	4.3
Chemicals	3.0	3.8	0.8	26.7%	3.8	4.5
Leather	3.1	1.9	-1.2	-38.7%	4.0	2.3
Primary Metals	19.6	21.0	1.4	7.1%	25.1	25.1
(Major Water-Using Industries)	(36.9)	(39.5)	(2.6)	(7.1%)	(47.2%)	(47.2%)
Apparel	17.4	16.0	-1.4	-8.0%	22.3	19.1
Nonelectrical Machinery	5.0	6.7	1.7	34.0%	6.4	8.0
Fabricated Metals	4.9	5.0	0.1	2.0%	6.3	6.0
Other	14.0	16.5	2.5	17.9%	17.9	19.7
Total Manufacturing	78.2	83.7	5.5	7.0%	100.0%	100.0%

Source: State Departments of Labor and Industry, New Jersey and Pennsylvania County Business Patterns, 1962.

X.D.3 SOCIAL CHARACTERISTICS

A major area of concern over the Tocks Island Lake Project is the potential effects of the intrusion of tourists and the attendant commercial, residential and other developments upon the lifestyle of the impact area residents. While the subject of lifestyle impacts is treated more fully in Chapter XXIV of this study, the following briefly illustrates the existing social characteristics of the impact area residents and presents a brief sketch of their present way of life.

Age, income and occupational profiles provide insights into the socio-economic structure of the residents of the seven-county impact area. As

shown in the following three tables, the impact area has a slightly older, middle-income and blue-collar population relative to the Northeast, United States and the nation as a whole.

Table 10-10 Distribution of Population by Age Group, Tocks Island Lake Impact Area, Northeast and United States

	Percent of 1970 Population in Age Groups			
	0-17	18-65	65 and Over	Total
Warren	33.4	55.3	11.3	100.0
Sussex	37.1	53.6	9.3	100.0
Orange	34.4	54.8	10.8	100.0
Sullivan	31.2	55.7	13.1	100.0
Monroe	30.4	57.6	12.0	100.0
Northampton	31.0	58.4	10.6	100.0
Pike	30.2	53.1	16.7	100.0
T.I.L. Impact Area	33.0	56.0	11.0	100.0
Northeast	32.7	56.7	10.6	100.0
Unites States	34.4	55.7	9.9	100.0

Source: U.S. Census of Population, 1970.

As shown in the preceding table, the Tocks Island Lake Impact Area has a relatively older population as is the case with many rural areas. The area has experienced some out-migration of the young often after high school graduation seeking economic opportunity in the larger cities. Sullivan and Pike counties have particularly large portions of their populations over 65 years of age. Sussex and Orange counties have a relatively larger proportion of population under 18 years of age. Overall, 11.0 percent of the impact area population in 1970 was 65 years of age or older compared

to 10.6 percent for the Northeast and 9.9 percent for the nation as a whole. Pike and Sullivan counties had particularly large portions of elderly residents with 16.7 percent and 13.1 percent, respectively of their population over 65. Sussex and Orange counties were the only counties to match or exceed the national percent of population under 18 in 1970.

The T.I.L. Impact Area in 1970 has a relatively large proportion of working-class blue collar workers and a smaller proportion of managers and professionals than the Northeast and the nation. However, occupational profiles within individual counties give some contrasting characteristics as shown in the following table.

Table 10-11 Distribution of Workers By Occupational Group, Tocks Island Lake Impact Area, Northeast and United States, 1970

	Percentage of 1970 Workers by Occupational Group				
	Professional Technical and Managerial	Sales and Clerical	Blue Collar	Service	Total
Warren	18.5	20.0	50.4	11.1	100.0
Sussex	25.0	23.6	41.4	10.0	100.0
Orange	23.5	22.5	40.0	14.0	100.0
Sullivan	23.3	20.7	34.1	21.9	100.0
Monroe	19.5	20.5	46.3	13.7	100.0
Northampton	17.2	19.5	52.8	10.5	100.0
Pike	24.2	19.5	42.1	14.2	100.0
T.I.L. Impact Area	20.8	21.0	45.5	12.7	100.0
Northeast	24.1	27.2	36.6	12.1	100.0
United States	23.1	25.1	39.0	12.8	100.0

Source: U.S. Census of Population, 1970.

Over 45 percent of T.I.L. Impact Area residents were blue-collar workers compared to 36.6 percent for the Northeast and 39.0 percent of the nation's workers. On the other hand, 20.8 percent of the impact area's residents were professional and managerial workers compared to 24.1 percent and 23.1 percent for the Northeast and United States, respectively. Sussex County was the only county above the national norm in professional and managerial residents while only Sullivan County had a lower percent of blue-collar workers.

Most of the T.I.L. residents are concentrated in the lower-middle and middle-income brackets in 1970. Smaller portions of its families were on the extreme ends of the income spectrum than either the Northeast or United States. Only Sussex County had more than the national average of families earning over $25,000 and it was still well below averages for the Northeast. Pike and Sullivan counties were the only counties with greater than average concentrations in the lowest income bracket.

Table 10-12 Distribution of Families by Income Level, Tocks Island Lake Impact Area, Northeast and United States

	Percent of Families by Income Level					
	$0- $4,999	$5,000- $9,999	$10,000- $14,999	$15,000- $24,999	$25,000 and over	Total
Warren	14.4	34.6	32.4	15.6	3.0	100.0
Sussex	11.5	32.3	32.2	19.0	5.0	100.0
Orange	15.8	33.2	30.8	16.5	3.7	100.0
Sullivan	21.6	35.9	26.5	12.6	3.4	100.0
Monroe	18.2	40.7	27.7	11.3	2.1	100.0
Northampton	13.5	36.3	32.1	14.7	3.4	100.0
Pike	23.5	38.5	24.2	11.5	2.3	100.0
T.I.L. Impact Area	15.2	35.0	30.9	15.4	3.5	100.0
Northeast	15.5	31.4	28.7	18.6	5.8	100.0
United States	20.3	32.5	26.6	16.0	4.6	100.0

Source: U.S. Census of Population, 1970.

As shown in the above table, T.I.L. Impact Area residents were concentrated in the $5,000-$15,000 income category in 1970. Almost 66 percent of the families fell into this category compared to just over 60 percent in the Northeast and 59 percent for the United States. Only 3.5 percent of the population made over $25,000 and only 15.2 percent under $5,000, lower than regional and national averages.

Based upon the foregoing and a substantial number of personal interviews with local leaders and residents, only generalized inferences can be made as to the present lifestyle. As noted earlier, a substantially detailed analysis of the impact upon the lifestyles of the local residents is made in chapter XXIV of this study. A broad, generalized and brief description of the present lifestyles follows.

The immediate impact area of the T.I.L. project is relatively isolated from the metropolitan influences of the New York Region. Most of the people live and work in small towns and in rural areas. This provides them with a life-style sharply contrasting with that of the more urban areas. Generally speaking, area residents possess a more relaxed, less congested, more informal lifestyle than their big-city brethren. These areas have fewer of the so-called "urban problems" of the metropolis. Their environment is pure, government is more accessible and everything seems to be more in control. A conservative philosophy prevails with its resistance to change and distrust of strangers and persons different from themselves reflecting a less stratified social hierarchy and the lack of significant segments of various racial or ethnic groups.

Local governments are often part-time operations in these rural/small town areas. Often there are few full-time paid employees and many of the government's functions are carried out by voluntary help and part-time employees. The people feel closer to their government because there are fewer of them and they can often take a direct role in its operation.

Generally, satisfaction with local government services is high. People consider local school systems and other government functions to be of good quality. Government officials are thought to be honest and well-meaning.

Many have consciously chosen their way of life over its urban alternative. They have forsaken commuting over congested roads and on mass transit for

any economic benefit that might bring. They have rejected the hostile attitude of aggressiveness and frenzied activity inbred in the city in return for a more leisurely pace, more friendly working environs and less crowding.

For many, it is an escape from urban problems. Air pollution, crime and racial conflict although not unknown in the more rural setting are less constant threats than in the city. The feeling is that they can cope with these problems while the big city has been enveloped by them.

For the most part, there is skepticism about change and a certain "coolness" to outsiders, a particularly important factor in their attitudes towards Tocks Island visitors. They are satisfied with a simple lifestyle and do not want to introduce new undefined influences in their lives.

The range of shopping, entertainment and service facilities and the range of economic opportunities is not as great as in urban areas. Home entertainment is a primary source of recreation. Shopping is normally done in small shopping areas with a limited variety of merchandise. Certain vital services, like medical care, are not always immediately accessible or as good as found in urban areas. However, impact area residents have consciously or by default traded off these urban-type benefits for the sake of maintaining their existing lifestyle.

In the more than a decade since plans for the Tocks Island Lake Project were first announced, many aspects of the proposal have been subjected to criticism from a variety of sources.

Areas of concern have been identified and have been aired on many occasions and public meetings. The criticisms can be organized into broad subject groupings. In this chapter, we have presented this material in nine sub-sections: Water Resources, Engineering, Electric Power, Economic, Land Use, Transportation, Social, Environmental and Project Formulation Concerns.

Inasmuch as this discussion is intended to focus on concerns and criticisms (and their review and evaluation), no attempt is made to present a balanced picture by exposing a variety of viewpoints around each issue. Therefore, it should be acknowledged at the outset that the Tocks Island project has enjoyed substantial support since it was first proposed in the early 1960's. Opposition to the Tocks Island project has also been widespread, with opponents requesting further examination of alternative solutions to accomplish the Corps of Engineers' stated objectives.

These criticisms and concerns have been identified from such sources as the hearings held before the Delaware River Basin Commission for their annual Water Resources Program, and for this Comprehensive Review Study, the hearings

held before the Congressional Appropriation Sub-Committees, clipping files of various agencies, the criticism file maintained by the DRBC and from direct personal interviews with local, state and federal government agencies and private interest groups. The purpose of this chapter is to identify all of these areas of criticism.

Many of the comments relate to issues which have been dealt with at length in other portions of this report. In these cases, reference is made to the relevant sections. Remaining issues are discussed in this chapter with professional evaluation where possible or appropriate.

Prior to the text of this chapter, a summary tabulation follows. Subjects of the criticis and concerns are identified with the proper page reference to Chapter XI, the appropriate cross-reference to more detailed information in other sections of the report or a summary statement of the material in this chapter.

Summary Chapter XI Tocks Island Lake Project Criticisms and Concerns

Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.A. WATER RESOURCES		
XI.A.1 WATER SUPPLY	XI-13	
XI.A.1(a) Water Allocation	XI-13	
XI.A.1(a)(1) Strategy	XI-13	Chapter III.E.2
XI.A.1(a)(2) Supreme Court Decree	XI-14	Chapter XVII
XI.A.1(b) Water Demand Projections	XI-14	
XI.A.1(b)(1) Municipal and Industrial	XI-14	Chapter III.B
XI.A.1(b)(2) Irrigation	XI-15	Chapter III
XI.A.1(b)(3) Electrical Power Plant Cooling	XI-16	Chapters III & V
XI.A.1(b)(4) Salinity Front Maintenance (3000 CFS low flow requirement)	XI-16	Chapter III.E.2
XI.A.1(c) Effect of Drought on Water Supply	XI-17	Chapter III, VII
XI.A.1(d) Alternatives (Water Supply)	XI-18	Chapter XII
XI.A.2 WATER QUALITY	XI-20	
XI.A.2(a) Pollution -		
Point and Non-Point	XI-20	Chapter IX.A.5(d), IX.F.2
Nutrient Trapping	XI-21	Chapter IX.H.1(a)
Thermal Pollution	XI-22	Chapter IX.H.1(a)
Soil Erosion	XI-21	Chapter X.A.5
DO Sag	XI-22	Chapter IX.H.2(a,(2)
XI.A.2(b) Eutrophication	XI-23	Chapter IX.A, VI.F.
XI.A.2(c) Salmonella	XI-26	Chapter IX.D.
XI.A.2(d) Soluble Beckmantown Limestone	XI-26	Soluble limestones may act as a nutrient source or flocculating agent. Net effect should be small and remain localized.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.A.3 HYDROLOGY	XI-27	
XI.A.3(a) Drawdown	XI-27	Chapter IX.B. During summer recreation season in average years, lake drawdown will be approximately seven feet. This will not seriously impair recreation uses, especially with beach areas sanded to elevation 385. In late summer and throughout fall, drawdown will approach 20 feet. This will expose extensive areas in the upper reaches of the reservoir. Much reshaping will be required to make 4 of the 7 proposed beaches workable in late summer and fall. During the autumn recreation and foliage season, large areas of the upper lake will be exposed and will most likely be without vegetation below elevation 400 and may have the appearance of cracked mud.
XI.A.3(b) Surges	XI-34	Chapter IX.B.1
XI.A.3(c) Groundwater/Water Table	XI-35	In the short term, the water table will drop during construction but will return to present or higher levels after reservoir is filled. Water supply in wells will be enhanced in the long run.
XI.B. ENGINEERING CONCERNS	XI-37	
XI.B.1 DESIGN AND CONSTRUCTION	XI-38	
XI.B.1(a) Dam Foundations	XI-39	Normal design considerations. Chapter VII discusses overall adequacy of Corps preliminary engineering design.
XI.B.1(b) Ice Conditions	XI-39	
XI.B.1(c) Earthquakes	XI-39	
XI.B.1(d) Sedimentation	XI-40	
XI.B.1(e) Stability	XI-40	
XI.B.2 FLOOD CONTROL AND ALTERNATIVES	XI-41	Chapter XV.
XI.B.2(a) Flood Plain Management	XI-41	Chapter XV.
XI.B.2(b) Other Existing Dams	XI-42	Chapter XV.
XI.B.2(c) Several Small Dams Instead of Tocks	XI-44	Chapter XV.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.B.3 FLOOD CONTROL ISSUES BEYOND SCOPE OF TOCKS	XI-46	
XI.B.3(a) Unprotected Areas	XI-46	Dams reduce chances of flood in proportion to drainage areas above and below dam.
XI.B.3(b) Harmful Affects of Dams	XI-46	Chapter II, XV.
XI.B.3(c) Loss of Life on Tributaries	XI-47	
XI.C. ELECTRIC POWER	XI-49	
XI.C.1 CONVENTIONAL HYDROELECTRIC AND PUMPED STORAGE POWER	XI-49	
XI.C.1(a) Allocation of Power	XI-49	The power that is generated by a power plant should be used in the most optimum way to meet the electric requirements of both the DRB and certain surrounding areas. Individuals throughout a region receive much greater benefits if the electric power which they use is derived from electrical generating resources which are integrated in such a way as to satisfy the total needs of the region.
XI.C.1(b) and (c) Pumped Storage/Blackouts	XI-49	Nuclear, fossil, hydroelectric and pumped storage plants are all susceptible to being forced out of service during critical electric substation and transmission line failures. There is no apparent reason why the reliability of pumped storage under such failure conditions, which could result in a "blackout period," is any less than for the other types of plants mentioned above. It is true that peak power alternatives, such as gas turbines and combined cycles, can be built in smaller sizes and located throughout the service area, thereby significantly reducing their loss of power as a result of major substation and transmission line failures.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.C.1(d) Pumped Storage/Air polution	XI-50	The use of pumped storage facilities in the overall generation mix would tend to reduce the air pollution potential. Pumped storage generation requires more energy for pumping water to upper reservoirs than is generated in its turbines; however, its use does tend to reduce the total air pollution. The reason for this is that pumped storage generation is used for peaking requirements, avoiding the necessity for using fossil thermal plants of relatively low efficiency which could be used for this purpose. Emissions to the atmosphere from use of the less efficient thermal plants is then eliminated. Furthermore, while most of the energy for pumping water to upper reservoirs would initially be provided by fossil fuel base load plants, the pumping energy provided by nuclear plants would start becoming significant in the early 1990's. As nuclear plants provide a greater share of pumping energy, air pollution decreases in proportion.
XI.C.1(e) Peaking Demands	XI-51	Pumped storage has been criticized in regard to supplying peaking demands because it requires 3 KWH's of energy to generate every 2 KWH's. Although a pumped storage plant does use more energy than it generates, the intent is to eventually use low cost off-peak nuclear energy for pumping so that fossil fuels are conserved. Gas turbines and combined-cycle plants, which are alternatives to pumped storage, have a greater overall energy utilization efficiency than a pumped storage plant, but require the use of rapidly diminishing fossil fuel resources and have higher operating costs.
XI.C.1(f) Sunfish Pond	XI-52	Results of detailed studies indicate that the reservoir and its expansion have not caused and will not cause any significant impairment of Sunfish Pond and its recreational, educational and ecological values - provided safeguards are employed.
XI.C.1(g) Destruction of Vegetation for Project and Power Lines	XI-52	The environmental impact of construction of tunnels and operation and construction of transmission lines will be confined to the disposal of spoil, ground water effects, possible subsidence and the appearance of the portals.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.C.2 ELECTRIC POWER DEMAND	XI-53	
XI.C.2(a) Electric Utilities Overestimate Power Demand	XI-53	Chapter V of this report examines power demand forecasting in some detail, and compares utility forecasts with "probable high" and "probable low" forecasts developed in this chapter.
XI.C.2(b) Peak Load Pricing Should Be Used	XI-53	Peak load pricing has been shown in many studies to have a definite effect in lowering electrical demand, but there still remains some uncertainty as to the degree of reduction which would be achieved. The analyses of Chapter V on electric power deal with the question of power demand and provide several analyses of demand reduction which could be achieved if peak load pricing is put into effect.
XI.C.2(c) Energy Conservation Should Be Considered	XI-54	Energy conservation measures could have significant effects in reducing demand. The effects of energy conservation on demand are also discussed in Chapter V.
XI.C.3 WATER SUPPLY FOR POWER	XI-54	
XI.C.3(a) Consider Power and Water Supply Together		The generation of electrical power has an important effect on water consumption and the relationship between power generation needs to be quantitatively examined. Water is used in many ways to provide important benefits to people. Electric power is also an extremely important benefit, and some water must be consumed in the process of generating the quantities of power that we use today and that will be used in the future. Estimates of the water needed by future power plants are made in Chapter V for several alternative situations.
XI.C.3(b) Past Demands Should Not Forecast Future	XI-54	It is true that future power plant water demand cannot be determined by extrapolating past demand. In Chapter V, future power plant water consumption is being forecasted by evaluating future power demand, the types of plants used to meet demand and the locations of these plants.

Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.C.4 FOSSIL AND NUCLEAR PLANTS	XI-56	
XI.C.4(a) Alternate Fossil Plants on Coast	XI-56	Interest has been expressed in the private development of a fossil-fueled plant on the coast that would serve the same load as TILP. A fossil-fuel base load plant, if operated to only supply peak load, such as is the purpose for TILP, would be very uneconomical, causing higher rates for the people using that power.
XI.C.4(b) Population Concentration vs. Nuclear Plant	XI-56	Chapter V
XI.C.4(c) Cooling for Limerick Plant	XI-56	Cooling water was originally to come from the Tocks Island Reservoir System. However, in the DRBC authorization to pump water from the Delaware was a statement to the effect that if by 1977 in the DRBC's opinion there is not enough water storage available in the Delaware for the Limerick station make-up water supply, Philadelphia Electric would provide their own reservoir to meet the Limerick needs.
XI.C.4(d) Radioactive Waste to TILP From Orange Rockland	XI-57	Concern has been expressed that if the Orange and Rockland Electric Company builds a nuclear power plant called Cliff Station above the Tocks Island Project, the radioactive wastewater will be going into a still reservoir, contaminating it. The potential radionuclide effluents from nuclear stations, such as Cliff Nuclear Generating Station, will be considered in accordance with EPA and NRC regulations should future applications be submitted.
XI.C.4(e) Use of Waste Heat	XI-57	Concern was expressed that not enough effort was directed to finding beneficial uses for waste heat from generating stations in the DRB. Several utilities, however, have studies underway. Pennsylvania Power and Light, Philadelphia Electric, and others are planning a three year aquaculture project on the Susquehanna River at the Brunner Island Steam Electric Station. Franklin Institute of Philadelphia will participate. Public Service Electric and Gas is carrying out an experimental trout farming project, and has completed an experiment to harvest shrimp.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.C.5 ALTERNATIVES	XI-59	Chapter XIV
XI.D. ECONOMIC CONCERNS	XI-60	
XI.D.1 PRIMARY AREA SERVICES SCHOOLS	XI-60 XI-61	Chapter XXII.C.4 NPS personnel and lease back or tenancy residents remaining in park do send some children to local schools. New Jersey State funds assist Sandyston and Walpack. No federal impact funds have been provided to date. TILP induced population growth impact on schools is not significant in proportion to normal growth.
XI.D.2 FISCAL IMPACT ON GOVERNMENT	XI-62	Chapter XXII.C.2(i)
XI.D.3 FINANCIAL IMPACT ON LOCAL RESIDENTS	XI-64	Local residents have been affected directly and personally by the T.I.L. project through loss of homes and breaking up of communities.
XI.E. LAND USE CONCERNS	XI-66	
XI.E.1 LAND ACQUISITION PRACTICES	XI-66	Some property owners were unhappy with results of land takings; many were satisfied. Corps of Engineers followed authorized government procedures. Many inequities and problems resulted from limitations of annual appropriations, prevention of co-mingling TILP and DWGNRA funds, patchwork of actual purchase pattern and long period of years during which purchase has been taking place. Federal Law PL91-646 has improved benefits and procedures for federal land acquisition.
XI.E.2 PRESENT USE DISLOCATIONS	XI-74	
XI.E.2(a) Residences	XI-77	Approximately 2,421 to 2,622 residences dislocated. Inevitable consequences.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.E.2(b) Summer Camps	XI-78	Summer camps have mostly been able to relocate or use other existing facilities in conjunction with other groups. Financial arrangements have benefited some, caused hardship for others. No camping opportunities seem to have been lost. With retention of Camp Mohican within the park and provision of group camping facilities, area camping opportunities will be as good or better than before.
XI.E.2(c) Agriculture	XI-82	Farm land to be inundated is among best farming land in TIL region, though limited in acreage by Kittatinny and Pocono Mountains. Farming becoming uneconomical in many areas regardless and speculative pressure exists on local farm properties. State farm legislation attempting to improve opportunities to keep farmland in agricultural use. Some good farm land would inevitably be lost to TILP.
XI.E.3 USE OF LANDS IF DEAUTHORIZED	XI-87	Chapter XIX
XI.E.4 MUNICIPAL VIABILITY	XI-87	Walpack and Pahaquarry Townships will become part of the DWGNRA when land acquisition is complete. This is an inevitable consequence, though the prolonged time period of tax base reduction while continuing municipal services has been a hardship. Villages of Bushkill and Dingmans Ferry will be inundated and although town centers will be rebuilt outside TILP-DWGNRA, they will not retain their original sense of continuity and community heritage.
XI.E.5 UNCONTROLLED DEVELOPMENT	CI-86	Chapter XXII.C.3
XI.E.6 FLOOD PLAIN LAND USE	XI-91	Chapter II.B.
XI.E.7 RATE OF RUN-OFF	XI-91	Construction will increase impervious surfaces. Water supply will not be affected, but erosion and sedimentation of streams and lake will be more likely unless new construction is designed with adequate drainage provisions and proper treatment of landscape. State policies and laws will help to provide these safeguards.

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.F. TRANSPORTATION CONCERNS	XI-93	
XI.F.1 IMPACT ON EXISTING	XI-93	Chapter XXV.
XI.F.2 EFFECT OF PLANNED IMPROVEMENTS	XI-94	
XI.G. SOCIAL CONCERNS	XI-97	
XI.G.1 LIFESTYLES	XI-97	Chapter XXIV.
XI.G.2 RECREATION CONCERNS	XI-98	
XI.G.2(a) Origin, Type and Quantity of Visitors	XI-99	Local officials and residents are presently disturbed by the estimated number of outside visitors to DWGNRA and by the potential conflict in cultures with those who will be visiting the area.
XI.G.2(b) Boating	XI-100	Chapter XVIII, F.1
XI.G.2(c) Swimming	XI-101	Drawdown XI.A.3(a) Eutrophication IX.A,VI.F
XI.G.3 HISTORIC	XI-102	Chapter XXII.C.5(a) and (b), Chapter X.A.6
XI.G.4 DESTRUCTION OF PROPERTY	XI-103	Many structures have already been razed. Remaining properties should be preserved for possible future uses pending final decisions regarding the project.
XI.H. ENVIRONMENTAL CONCERNS	XI-104	
XI.H.1 AQUATIC BIOLOGY	XI-104	
XI.H.1(a) Oysters	XI-104	Chapter VI.A.6, IX.H.2(b)
XI.H.1(b) Shad	XI-105	Chapter VI.A.6, IX.C.2
XI.H.1(c) Species Composition	XI-107	Chapter IX.C.1
XI.H.1(d) Reservoir Operation-Drawdown	XI-109	Chapter IX.A.3.(a)
XI.H.2 TERRESTRIAL BIOLOGY	XI-111	
XI.H.2(a) Wildlife Habitats	XI-111	Chapter IX.C.3, X.A.4
XI.H.2(b) Migratory Wildfowl	XI-112	Chapter IX.C.3, X.A.4
XI.H.2(c) Wildlife Mitigation Areas	XI-112	Chapter IX.C.3, X.A.4

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Area of Criticism or Concern	Page	Cross Reference or Summary Statement
XI.H.3 AIR POLLUTION	XI-113	Chapter XXV discusses automobile emissions. Construction-imposed air pollution loads will not have a significant effect.
XI.H.4 LOSS OF FREE FLOWING RIVER	XI-114	The loss of the free-flowing stretch of the Tocks Island area would be a loss of a major portion of the last freely flowing part of the Delaware River.
XI.I. PROJECT FORMULATION CONCERNS	XI-115	
XI.I.1 ECONOMIC	XI-115	
XI.I.1(a) Validity of Cost-Benefit Assumptions	XI-115	Chapter XVI.B
XI.I.1(b) Project Benefits and Local Economy	XI-117	Chapter XXII.C.2
XI.I.2 RECREATION	XI-118	
XI.I.2(a) Sufficiency of Existing Facilities	XI-118	Chapter IV.
XI.I.2(b) Compatibility of TILP with DWGNRA	XI-120	DWGNRA and TILP are compatible to the extent that reservoir operation and eutrophication do not present problems. See these subjects for discussion of the respective issues. In addition the impacts of visitation levels on the natural environment and the effects of the project on historic & archeologic sites are potential areas of incompatibility of TILP with DWGNRA.
XI.I.3 COMPATIBILITY OF PROJECT MULTIPURPOSES	XI-124	Chapter VIII

XI.A. WATER RESOURCES CONCERNS

XI.A.1 WATER SUPPLY CONCERNS

XI.A.1(a) Water Allocation

XI.A.1(a)(1) Water Allocation Strategy

Concern has been raised relative to the basis of the water allocation strategy of the Delaware River Basin Commission and the Corps of Engineers.

The water allocation strategy is based in part on the compact which formed the Commission. The compact places emphasis on allocation of water to the several States and then allocation of the water by the States to the ultimate users. There is an additional strategy implicit in the actions of the Delaware River Basin Commission over the years in terms of an allocation of water to the highest use. For example, municipal water would have priority over water used for irrigation.

During the drought of the 1960's when there was not adequate water for all users, water was allocated to municipal and industrial users at the expense of the generation of hydro-electric power implicitly assuming that hydro-electric power was of less value to the community.

Within the last ten years the DRBC has instituted a pricing policy based on the amount of water used consumptively beyond present allocations. Such a policy necessarily assumes that further consumptive use would have

detrimental effects in the basin. The primary detrimental effect associated by the DRBC with increased consumptive use is increased likelihood of salinity intrusion in the estuary. The likelihood of salinity intrusion and its relationship to the 3000 cfs requirements proposed by the DRBC is discussed in sections III.E.2 and XI.A.1(b)(4). While the water pricing policy of the DRBC is not directly of concern in this study, our findings on the likelihood of salinity intrusion would seem to require a re-examination of this policy.

XI.A.1(a)(2) Supreme Court Decree of 1954

Concern has been raised relative to the adequacy of the Supreme Court Decree of 1954 for allocating Delaware River Basin water, particularly during periods of drought emergency. This is an important concern because the planning that has been carried out in the basin since 1954 has considered this decree to be an inviolable requirement around which water resources must be planned. The possible ramifications of a change in the basic decree, or a more rational basis for allocating water under the decree during periods of drought emergency, both from a legal and a hydrologic viewpoint, is contained in Chapter XVII.

XI.A.1(b) Water Demand Projections

XI.A.1(b)(1) Municipal and Industrial

Several concerns have been raised relative to the validity of municipal and industrial water demand projections made in the original Corps report and by others in the intervening years. Some of the concerns have been

that the demands have been too high, others that they have been too low. As part of this study, the municipal and industrial demands have been re-projected. These projections and the methodology used are described in Chapter III.B.

Several concerns have been expressed relative to the consideration of local water requirements in the projection of municipal and industrial water demands. It has been suggested that projections have been made on a broad regional basis and local level requirements have not properly been taken into account. The Corps of Engineers in their report to Congress used, in our opinion, a very comprehensive and sound demand projection methodology. Economic sub-regions were defined and economic and water use data was collected at the county and lesser subdivision level as appropriate. While these demand projections were reported on an economic sub-region or larger region level, they reflected local level requirements as they were based on local level economic and water use data. A similar level of approach has been used in projecting the municipal and industrial water demands for this study as reported in Chapter III.

XI.A.1(b)(2) Irrigation

A concern has been raised relative to the proper consideration of irrigation requirements and also consideration of the fact that irrigation requirements occur primarily during a 60-day growing period. At the time of the Corps of Engineers report to Congress, irrigation in the humid east was just becoming important and there was little historical data from which accurate projections of future irrigation requirements could be made. Because 15 years have passed since these irrigation projections were made, a

good deal of historical irrigation data has accumulated and has been used in projecting irrigation requirements. The total irrigation requirement and methodology used in developing these requirements is contained in Chapter III.

XI.A.1(b)(3) Electric Power Plant Cooling

Electric power generation has a significant historical and potential demand on the Delaware River Basin. Power plants can use very large amounts of water consumptively, particularly nuclear units with evaporative cooling. Recent EPA regulations which discourage the use of once-through cooling and thus require evaporative cooling have significantly increased the potential use by power plants. Electric power plant cooling requirements have been projected based on expected future electric power demands, electric power generation technology projections and projections relative to the technology of cooling. High, low and most probable projections have been made so as to give an indication of the range that can be expected. These demands and the methodology applied are reported in Chapter III. Also see Section XI.C of this chapter for a discussion of power plant related criticisms.

XI.A.1(b)(4) Salinity Front Maintenance

A number of concerns have been raised relative to the effect of the construction of Tocks Island Dam on the movement of the salinity front and also, more importantly in our opinion, the validity of the 3,000 cfs low flow requirement expressed by the Delaware River Basin Commission.

Tocks Island Dam would have a beneficial effect in terms of keeping the salinity front from moving up the estuary and threatening the water supplies of Philadelphia and Camden if indeed there were any significant probability that this could happen. Section III.E.2 indicates that even under conditions of consumptive use in 2025, the probability of exceeding a salinity standard of 50mg/l is low. Additionally, the magnitude of exceedance when it does occur is less than 100 mg/l which in turn is much less than the maximum salinity standard of 250 mg/l recommended in the U.S.P.H.S. drinking water standards. Analyses conducted during the course of this study indicate that the salinity encroachment problem is not severe enough to demand a 3000 cfs low flow requirement.

XI.A.1(c) Effect of Drought on Water Supply

A concern has been raised relative to the validity of probability evaluations carried out to establish the return period or frequency of a drought of the magnitude observed in the early 1960's. This is an important consideration. If such a drought is likely to occur in the near future (10 to 30 years), it will certainly be important to employ measures which will assure that adequate water supply and salinity front maintenance can be provided. If such a drought is not likely to occur or would occur only on the average over much greater periods of time (100 to 1,000 years), a large capital expenditure on works within the basin would have to be much more carefully evaluated. Because the essence of establishing a return period for a drought is dependent upon describing the event (establishment of certain low flows over certain periods of time, all necessarily arbitrary) we believe it is much more important to establish the return period or frequency of the effects of the drought. Such effects would include the en-

croachment of a salinity front toward the Torresdale intake and Camden aquifer or short falls in diversions from the Delaware to the City of New York. The results of our evaluations are contained in Section III.E.2. The concept of drought and drought frequency has been an issue central to much of the disagreement over the proposed Tocks Island Dam. In Chapter VII, we have provided a critical review of the use of probability concepts in the original basin planning and in the various reports that have been prepared over the years on water supply in the Delaware Basin.

XI.A.1(d) Consideration of Alternatives

A number of concerns have been expressed relative to the proper consideration of alternative means of water supply other than by the Tocks Island Project. The original report to Congress by the Corps of Engineers proposed the Tocks Island Project as a very cost effective means of managing water supply in the Delaware River Basin. Consequently, the alternatives which may have provided the same quantity of water but at a higher cost were essentially not given as much consideration. Cost effectiveness has been the basis for consideration of the alternates of providing water from within the basin and of providing water from outside the basin. Means of providing water from sources outside the basin were not in the original scope of the study by definition. Later, when concerns were raised about alternative means of providing water, such alternatives were generally discarded if they were not as cost effective as Tocks Island.

Chapter XII contains our investigation of long term alternative means of providing water as well as short-term or emergency means during low flow or drought conditions. Alternatives considered include those raised in

many of the concerns and criticism expressed such as: (1) alternative reservoir siting both within and without the basin; (2) Hudson River sources; (3) desalinization; (4) wastewater reclamation; (5) metering; (6) water conserving devices; (7) demand reduction; and (8) high flow skimming.

XI.A.2 WATER QUALITY

XI.A.2(a) Pollution

Concerns have been expressed over the pollution of the upstream and downstream areas, and the effects of the Tocks Island Lake Project on these existing conditions. Concerns related to the direct pollution of the impoundment will be covered in the following section on eutrophication.

In the upper reaches of the Delaware River pollution from agricultural runoff and municipal waste effluent are a prime concern. Runoff from fertilization, erosion from soil practices, and entry of poultry wastes are feared the prime contributors to eutrophication within the proposed reservoir. Currently, poultry wastes are spread on cultivated fields as a fertilizing technique. The spreading may not occur at the best time of the year or in the most feasible manner, resulting in runoff and odor problems.

Significant concern exists as to how easily this practice can be controlled or if the control is economically feasible. If such controls were instigated, the question remains as to the survival of the poultry industry in the area. As indicated in Chapter IX.A.5(d), the nutrient contribution of upstream sewage dischargers is approximately equal to the non-point contributions, but is substantially easier to control because of easier source identification, well-developed control measures, and the availability of federal funding. A more thorough discussion of the effectiveness and costs of reducing both upstream point and non-point contributions in order

to improve lake water quality is contained in Chapter IX.F.2. In summary, agricultural pollution (non-point source) poses much greater concern than point source discharges due to fewer well-known techniques for control, lack of federal funding and the fear of economic repercussions.

Concerns related to downstream conditions include the production of sediment during construction and its entrapment during reservoir operation, the reservoir release of water high in nutrients, the potential for increased pollution-causing development and possible spatial changes in the Philadelphia-Camden dissolved oxygen sag.

Concerns have been expressed that substantial erosion will result from the devegetation occuring during the construction phase. This practice is also feared to increase both the turbidity and nutrient level of the free-flowing Delaware River during construction. The result would be a general decrease in downstream oxygen levels.

Others stress the ability of the physical structure of the dam to trap sediment on the floor of the impoundment. This could cause sediment starvation of the downstream reaches. This sediment ordinarily would be deposited in the estuary and, during occasional heavy storms, upon the floodplain. A portion of the organics made available to vegetation in the floodplain and aquatic organisms of the bay would be lost. The short-term effects of construction-generated sediment are outlined in Chapter X.A. Because these are expected to be severe at times, it has been suggested that the Corps of Engineers strictly follow their rules

and regulations on sediment control. The long-term effects of construction-generated sediment will not be significant.

The releasing of water from the dam could serve as one means to control the level of nutrients within the dam. Concern has been expressed that in an attempt to control the nutrient level of the reservoir, the quality of downstream waters will be affected. Some individuals have stated that the construction of the reservoir will increase the water quality of the downstream reaches. The effects of downstream releases on lower Delaware River water quality are covered in Chapter IX.H. It was shown in that section that the multi-level intake feature of the reservoir outlet will allow for the potential optimization of reservoir and downstream water quality.

With regard to thermal pollution, the main stem of the lower reaches of the Delaware River may be affected if waters are drawn from the bottom of the impoundment. These discharges of colder than ambient waters could be detrimental upon fish and wildlife in the downstream reaches. Thermal effects are not expected to be significant due to the multi-level intake structure and the water quality regulations governing the Delaware which limit the magnitude of temperature changes. Once again a complete discussion is contained in Chapter IX.H.

Concern has also been expressed about the possibility of downstream water quality degradation due to the secondary effects of floodplain development. Lastly, increased flow as a result of the Tocks Island discharge

may literally push the dissolved oxygen sag now located in the Philadelphia-Camden area downstream. Degradation of water quality near existing developed areas is amply described in Chapter VI.A. With stricter control of municipal and industrial effluent quality and of both combined and separate urban stormwater runoff, the effect of future developments on water quality will be reduced but certainly not eliminated. The movement of the dissolved oxygen sag with increased flows is outlined in Chapter IX.H. Whether or not the reservoir operation will affect the dissolved oxygen sag will depend on the schedule of operations to be followed by the Corps of Engineers.

XI.A.2(b) Eutrophication

The primary concerns expressed with regard to eutrophication potential include nutrient source identification and quantification, organic debris decomposition, and possible recreational effects.

The area of inundation contains a great deal of rich farm soils. When inundated, these soils might release large amounts of nutrients to the lake waters. Concerns have also been expressed as to the additional amounts of nutrients leached into reservoir waters from the fill material used in shaping the reservoir bottom and the sediments deposited into the impoundment from the erosion of reservoir banks exposed during pump operations. Although the state-of-the-art has not progressed to the point where the quantitative effect of these inputs on eutrophication can be determined, nutrient release from these sediments will increase the short-term eutrophication potential, as pointed out in Chapter IX.A., but will not substantially affect the long-term potential as the sediments will be covered

with organic detritus.

Other nutrient sources include that originating from the decay of incoming organic material and inundated uncut brush and vegetation, the droppings of migratory birds, and the alkaline waters from inundated limestone quarries.

This organic material will be made up primarily of watersoaked leaves from deciduous trees in the area. The organic debris settling to the bottom of the impoundment will be subject to decay. The biochemical oxygen demand of such decaying material may cause the lower level (hypolimnion) in some areas to become nearly anaerobic from the months of late July through late September. The water is expected to have a high CO_2 content, a low pH value, high amounts of H_2S, CH_4, humic acids and tannins, which would be extracted from the partially decaying organic materials. Areas subject to such conditions should be of limited extent, located mainly near the mouth of small tributaries. These materials should have little effect on the overall DO in the lake hypolimnion. Although no mitigation measures have been suggested for this potential problem, aeration to increase the DO levels or dredging to remove the organic sediments are possible mitigation measures available to reduce potential degradation. As these areas should be of small areal extent, such measures might be economically justified if sufficient recreational usage at the site was initiated due to the water quality improvement.

Because the lake is phosphorus-limited, increased alkalinity from limestone dissolution should not increase the eutrophication potential. The nutrient and organic load imposed on the lake by the decay of inundated brush and vegetation will be significant in the first couple of years, but would not

be important in the long-run due to degradation and hydraulic flushing. The droppings of migratory birds should not be significant in the short-run or long-run.

The interaction between Tocks Island Lake water quality and recreational usage has been noted. Some fear that a decrease in water quality due to eutrophication will sharply curtail its utility for recreation during the prime summer months, while others are worried that the sewage produced by visitors drawn to the area will need to be extensively treated in order to protect lake water quality. They feel that the sewage would need complete tertiary treatment to remove as much of the phosphates and nitrates as possible before the effluent enters the reservoir.

As indicated in Chapter IX.A., some degree of eutrophication will occur which may tend to modify the location and intensity of certain recreational uses. The other contemplated uses of the lake (flood control, water supply and electrical power generation) are not expected to be affected by lake eutrophication. Application of strict phosphorus removal standards to sewage effluents entering the impoundment is mandated by the DRBC waste disposal plan and may be mandated by Section 314 of PL 92-500, which sets forth a program to evaluate and improve the water quality of the nation's lakes. As pointed out in IX.A.6(e) and IX.F.2, some control of both point and non-point sources will be necessary to limit the eutrophication potential.

A concern exists as to which nutrients should be classified as limiting in the eutrophication of water bodies and the levels of nutrient removal to be provided by waste treatment facilities. As mentioned in the section on

nutrient resources, phosphorus is the limiting nutrient and the DRBC is mandating 95 percent removal of phosphorus from sewage effluents entering the impoundment.

XI.A.2(c) Salmonella and Other Public Health Questions

The upper reaches of the Delaware River are bordered by agricultural lands of which poultry farms form a high percentage. Runoff from the poultry farms entering the river could conceivably introduce a sizable population of *Salmonella*. The presence of *Salmonella* in the impoundment could, in turn, present a potential health hazard to recreational use. The fecal matter of migrating ducks and geese released near or in the lake could raise the potential of *Salmonella* contamination. A complete discussion of the negligible recreational health hazard expected is contained in Chapter IX.D. Therefore, no mitigation measures have been suggested or are necessary.

XI.A.2(d) Soluble Beckmantown Limestone

The potential encouragement of eutrophication by alkaline waters has already been identified and evaluated in the eutrophication section above. The potential action of the limestone as a flocculating agent increasing bottom sediments has also been identified. Considering the volume of the reservoir and its residence time, it is extremely doubtful that the limestone concentration in the reservoir would be high enough to cause large-scale flocculation. Near the mine itself, flocculation and enhanced deposition may occur. No mitigation measures are necessary due to the limited extent of the problem.

XI.A.3 HYDROLOGY

XI.A.3(a) Reservoir Drawdown

Several concerns have been expressed relative to the operation of the reservoir which would produce fluctuations in lake levels, thereby effecting the aesthetic qualities of the lake, and generally impairing recreational use.

In the Corps of Engineers 1971 Final Environmental Impact Statement, the following describes the reservoir "drawdown":

> "In the course of an average year's operating cycle, drawdown of the lake would total 18 feet, although it could be as little as 2 feet or as much as 57 feet. This latter event has a one percent chance of occurrence. During the 14 weeks of the prime summer recreation season, the operating program for the lake would result in an average drawdown of only 7 feet, or less than one inch per day."

This information can be compared to a computer analysis of the Distribution of Daily Reservoir Elevations by Month derived from water level information available over a period of about 52 years of record. This analysis was prepared by the Corps of Engineers. Table 11-1, which follows, indicates probable elevation ranges of the Tocks Island Lake as determined from this computer analysis.

Table 11-1 Probable Elevation Ranges For Tocks Island Reservoir

	June	July	Aug.	Sept.	4 Mo. Max. Range of Drawdown
1. Total Days of Record	1567	1612	1612	1560	-
2. 95% of 1	1488	1537	1531	1482	30 ft.
Elev. Range For 2	413 - 402	413 - 399	409 - 392	407 - 383	
3. 90% of 1	1410	1451	1451	1404	26 ft.
Elev. Range For 3	413 - 406	412 - 399	409 - 396	407 - 389	
4. 85% of 1	1332	1370	1370	1326	22 ft.
Elev. Range For 4	412 - 405	412 - 402	408 - 395	406 - 390	
5. 80% of 1	1254	1290	1290	1248	21 ft.
Elev. Range For 5	412 - 406	412 - 403	407 - 398	404 - 391	
6. 50% of 1	784	806	806	780	16 ft.
Elev. Range For 6	410 - 408	408 - 403	404 - 400	401 - 394	

In each instance of range the highs and lows represent extremes about an average or median elevation and give an indication of possible lake elevations in the summer recreation months. Line 6, or 50% of the days of record, is a fair approximation of the average conditions with the high and low figures at 95% on Line 2 showing the less likely extreme possibilities.

Table 11-2, below, tabulates the mean elevations of Tocks Island Reservoir for each month, derived from the same source material. These are the lake elevations for which it can be said that 50% of the time elevations will be above and 50% of the time they will be below.

Table 11-2 Tocks Island Reservoir Monthly Mean Elevations

January	400	July	407
February	400	August	402
March	407	September	397
April	413	October	391
May	411	November	392
June	409	December	398

As the normal summer recreation season runs from Memorial Day to Labor Day, the mean fluctuation from June through August is 7 feet which corresponds to the Corps EIS statement.

Table 11-3, taken from the Corps of Engineers General Design Memoranda, describes total lake acreage at differing elevations both of flood and drawdown and indicates areas either exposed or covered by reason of lake operations.

Table 11-3 Acreage Affected by Reservoir Fluctations

Elevation	Lake Acreage	Level Change	Acres Flooded or Exposed	
436	18,280	+26	5,855	
432	17,230	+22	4,805	Acres Flooded
420	14,365	+10	1,940	
415	13,410	+ 5	985	
410	12,425	0	-	
405	11,540	- 5	885	
400	10,650	-10	1,775	
390	8,905	-20	3,520	
380	7,085	-30	5,340	Acres Exposed
370	5,750	-40	6,675	
356	4,170	-54	8,255	
340	2,510	-70	9,915	

Source: Corps of Engineers General Design Memoranda #2, 1969.

The consequences or implications of this lake operation information are related to lake aesthetics, recreation facilities, aquatic plants and fish and wildlife.

For purposes of this discussion, the first two subjects will be treated in this chapter. The latter two have been treated in Chapter IX.B. for vegetation and IX.C. for fish and wildlife.

A drop of 5 feet of the water level would expose approximately 1,000 acres. A drop of 20 feet, close to the average yearly maximum, would expose 3,600 acres or approximately 158,000,000 square feet. Much of this square footage would be situated within the 80 percent of shoreline sidings considered steep. A sizeable portion, however, would also be situated within the northern reaches of the lake, which have less slope and would result in mudflats.

A primary step in construction of the Tocks Island Reservoir is to clear the vegetation to the high water mark. The existing substrate, which will also be the remaining substrate after devegetating, is composed of solid, compact soils ranging from fine particulate aluvium to the coarser soils forming the cliffside terrains. Upon devegetation, it is these soils which will remain exposed. The term "mudflat" usually connotes a wide expanse of very soft, jelly-like substrate yielding the unpleasant odor of rotten eggs. Although unpleasant, these areas are extremely valuable to the marine and estuarine habitat. Tocks Island Lake region will have neither the sediments, characteristic detritis accumulation, nor the high influx of organic matter to create the usually envisioned "mudflat".

In Chapter IX, it was indicated that down as far as elevation 400 it can be expected that rooted aquatic plants may become estabished. Below 400, no vegetation can be anticipated. Another condition indicated in Chapter IX is the possibility of periphyton algae growth which will cling to rocks and hard surfaces and when exposed by drawdown will at first present a "slimy" appearance. After the first few days of drawdown exposed periphyton algae, rooted aquatics, and any floatable plant-life settling on the mudflat will die and decompose.

The lake, over its 100 year life span, will, according to Corps calculations, house an accumulation of some 19,000 acre-feet of sediment storage. Of this river silt brought down into the lake, about one-third may be expected to be deposited above normal pool elevations from periods of flooding, about one-third will find its way to the deepest portions of the impoundment, and the remaining one-third will be in areas exposed during periods of drawdown. This silt layer tends to concentrate its deposits primarily in delta or shallower areas at the upper reaches of the reservoir. It is conceivable that in the 100 year period, a layer as much as two feet deep could be built up in some areas.

This river silt layer will produce, when exposed by drawdown, a dry, cracked mud condition, which when wet is heavy and gummy and becomes extremely hard when dried by exposure to the sun.

The Conceptual Development Plan for TIL-DWGNRA, prepared by Clarke and Rapuano, is delineated on a series of drawings at a scale of one inch equal to 800 feet. Contours are drawn at five foot and/or 25 foot intervals with spot elevations indicated as well. This topographic base mapping was provided to Clarke and Rapuano by the National Park Service, where it was received prior to preparation of the original 1966 NPS Plan. It was prepared for the Army Corps of Engineers from

aerial surveys and, besides U.S.G.S. quadrant mapping, appears to be the only available comprehensive topography of the area. The Conceptual Development Plan delineates the lake at normal pool elevation of 410, represents flood elevation of 432, and defines a drawdown of 20 feet to elevation 390.

As shown in Tables 11-1 and 11-2, this 20 foot drawdown is not anticipated during the average summer recreation season. It can be expected to occur infrequently in late summer, to a greater extent in September, and frequently throughout the autumn months until pool levels begin to increase again in December.

Using the Clarke and Rapuano drawings as reference, it can be seen that much of the lower and central lake areas will not experience extensive areas of exposed mudflat. There will, however, be certain portions of inlet extremities such as Bushkill and Flatbrook near Walpack Center and portions of Walpack Bend, which will have large areas exposed. The major concentrations of mudflats will be in the northern portions of the lake where many areas will return to the confines of the river bed at 20 foot drawdown.

In terms of recreation facilities, several of the boating or picnic areas will be left far from the lake waterfront. These would include some of the areas at Bushkill, all the water's edge facilities at Tillman Creek, picnic and boating facilities at Dingman's Creek, and picnic sites at Minisink and at Millville. In some cases the distances could be in the range of one half mile.

The Corps indicates that "beaches and boat beaching areas proposed for recreational developments along the shoreline are planned to be constructed with sand-covered slopes within the recreational season drawdown zone" (1971 EIS). This

has been designated as elevation 385.

In Clarke and Rapuano's text to the Conceptual Development Plan, they indicate that "the most feasible sites have been selected for the swimming beaches.... only Millville and Tom Quick appear to be marginal sites because of their confined situation on a narrow section of the lake.... All of the sites will require extensive grading and shaping."

When studying the beach sites, Van Campens, Poxono, and Sandyston are the only beach areas where extensive dredging, land contouring or regrading would not appear to be necessary to make the beach areas usable as drawdown moves into lower ranges in late summer. While Minisink Beach is sited at a reasonable gradient, immediately upriver is an extensive area which will become mudflat as the lake recedes toward the original riverbed. Perhaps this could be modified by channelization which might create an island. Dingman's Creek Beach and island picnic area become landlocked as the water recedes to the river side of the planned island. Here too, much channelization would be needed.

Further north, the beaches at The Cliffs and Tom Quick, which remain for development in later phases, would require considerable regrading and dredging to prevent the reservoir from receding to the original riverbed at great distances from the presently conceived beach areas during later stages of drawdown.

The Millville Beach has been eliminated from the plan. This area lies on a bend in the river just opposite Milford. During drawdown months, this large area will be left as mudflats.

Though it appears that during the main water recreation season, the lake levels will not usually impair water activities, as the summer ends, and during the entire fall season, drawdown will frequently present the Tocks Island region with many acres of unattractive bare areas. Within the DWGNRA boundaries, an area take-off prepared from the Conceptual Plan drawings indicates 2,744 acres of exposed terrain at lake elevation 390. (This compares with 3,520 acres indicated in Table 11-3, but does not include any drawdown above the DWGNRA boundary at Mashipacong Island).

During the fall foliage recreation season, the area's beauty, especially at the head of Flatbrook Inlet and lake reaches above Namanock, will be marred by the effects of drawdown.

XI.A.3 (b) Surges

There is concern relative to the possibility of surges as a result of releases from the Tocks Island Lake. It is very unlikely that water will be released too quickly from the reservoir, causing a bore to travel down the Delaware River, endangering or overturning small boats. This is due to a change in the design and operation concept, which will be similar to the Kinzua Dam and pumped storage power plant located at the Allegheny River Reservoir, near Warren, Pennsylvania. This dam and power plant has been in operation over three years with beaches, marinas and other recreational facilities downstream and has never experienced a boating accident due to surges as a result of releases from the reservoir or power plant.

There will be five power units, two of which will discharge into the lake and three which have double draft tubes and will be able to discharge into the lake or downstream of the dam via the tailrace tunnel, stilling basin and

discharge channel, all of which are designed to eliminate surges.

In addition to the hydraulic design features, the operation will be in discrete increments, and the downstream flow would be based upon that designated by the Corps of Engineers, or a minimum of about 2800 cfs. Each tandem auxiliary can discharge in increments of 1,300--1,800 cfs, thereby eliminating any appreciable surge or stream fluctuation following the 40 foot deep stilling basin and discharge channel.

Operation of the Tocks Island Reservoir, dam and hydropower facility will be done in a way that carefully controls the effects of water discharges or releases. Such controls, as previously described, are necessary to avoid damage to the outlet works through cavitation, erosion or other physical forces which would damage or destroy them. Flows are increased in gradual increments, and controlled in such a way that bores or flood waves are not likely to occur.

XI.A.3(c) Water Table

Concern has been raised relative to the impact of the Tocks Island Lake on the groundwater resources of the surrounding area. In the vicinity of the Lake there will be a twofold effect. There will be a short-term effect due to the construction activities of the dam itself, and a long-term effect after the reservoir is operational.

The construction of the dam will require considerable excavation for the abutment on the New Jersey side of the River. Groundwater will seep through the excavation, resulting in a temporary lowering of the groundwater levels.

After construction is complete, the groundwater will return to its previous elevation and will not create an adverse environmental impact. Other changes will occur during the construction as a result of cuts and fills for regional highway reconstruction. The effect on groundwater is considered minimal and the drainage resulting from such groundwater discharges can be easily accomodated.

After the reservoir is filled, a rise in local groundwater levels will occur. A beneficial effect of this raising will be that it will be easier to pump from wells because the levels in the wells will be higher.

The permanent level of the lake has been kept low enough that basements in the Matamoras-Port Jervis area will not be flooded by the raised water table. Temporary surges such as the passage of floods will have no influence on water table level but do require construction of dikes and levees to prevent backwater flooding of basements due to the temporary flood conditions.

XI.B. ENGINEERING CONCERNS

The concerns which have been expressed with regard to the engineering aspects of the proposed project are related, principally, to what might happen if the project is constructed. The expressions disclose that the information reviewed by the critic was insufficient to dispell the concerns. Either the concern has not been treated or it has not been treated in adequate detail.

These concerns may be divided into four main categories. The first relates to hard engineering matters, i.e., matters which can be estimated quantitatively by established procedures, by model tests, or other engineering techniques. Concerns in this category include those related to:

1. Adequacy of the foundation for the dam
2. Potential damage due to earthquake
3. Silting of the reservoir
4. Influence of ice flow on the reservoir and dam during and after construction

In the second category, are concerns which relate to the quality of the construction.

In the third category are concerns that the preliminary engineering evaluation has not adequately considered all alternatives. For example, with regard to the flood control aspect of the proposed project,

there have been several expressions of the view that instead of damming the river, flood control should assume a passive posture wherein the floods are permitted to occur, or damage is obviated, or mitigated via flood plain management. Other examples include:

1. Regulate New York City reservoirs to minimize flood flows.
2. Construct a number of smaller, off-river dams instead of the larger on-river dam.

Also in this category are several comments related to the water supply aspect of the proposed project. These are considered in Section XI.A.1 of this chapter.

In the fourth category are concerns as to what the proposed project will not accomplish. For example:

1. The proposed project will not stop flooding in the tributaries to the main stem of the river.
2. The proposed project will not stop flooding in the lower (tidal) area of the river.

XI.B.1 CONCERNS REGARDING ADEQUACY OF THE ENGINEERING DESIGN AND QUALITY OF THE CONSTRUCTION

The engineering design is discussed in Chapter VII. Final plans and specifications for the entire project have not been prepared. Work to date is contained in Corps of Engineers Design Memoranda which have been reviewed. It is assumed that the final engineering design will be competently performed; it should have the usual system of checks and

reviews and adequate inspection of the construction should be provided to assure conformance with the project plans and specifications. It should be noted in this regard that certain aspects of the total planning and design effort are normally performed in the final design phase of a project, and if they can be readily handled at that time, need not be addressed in preliminary planning phases.

XI.B.1(a) Dam Foundations

With specific regard to the matter of adequacy of the foundations, reference is made to Design Memoranda No. 6, "Site Geology" and No. 9 (including Supplement No. 1) "Embankment and Foundations". Review of these memoranda indicates that the pertinent investigations and engineering evaluations have been performed thoroughly and to professional standards. Further, it is noted that the design has been guided, reviewed, and approved by an expert Board of Consultants.

XI.B.1(b) Ice Conditions

With specific regard to the problem of ice pressure on the dam, while we do not find specific reference to this matter in the Design Memoranda, it is noted that the problem is well known, is the subject of extensive engineering literature, and generally is a consideration in final design phases. There is no reason to believe that the dam will not be designed to accomodate ice flowing down into and forming on the lake.

XI.B.1(c) Earthquakes

Likewise, there is no reason to doubt that the problems of fault identifi-

cation and the effects of earthquake on the dam and reservoir will not be adequately considered in the final construction documents. This matter too, has been extensively researched and is well within the province of adequate engineering evaluation. Study of Design Memoranda No. 6 (Section 4 and 6) and No. 9 (Section 5) indicate that seismic factors have been thoroughly considered and that such factors (spontaneous liquification in particular) are the controlling feature in the foundation design, requiring flat slopes to the embankment, use of high strength materials, removal of suspect soil materials, and use of foundations shear keys.

XI.B.1(d) Sedimentation

With specific regard to the problems of sedimentation of the reservoir, the Corps of Engineers reports that "the Delaware River and tributaries normally carry comparatively little sediment (and that) there are 19,000 acre-feet of reservoir storage set aside for the purpose of containing sediment deposited within the lake." The General Design Memorandum (Section III) also discusses this problem and, based on the projected silt loads presented therein, the above-noted storage volume will adequately contain a 100-year accumulation of sediments.

XI.B.1(e) Stability During Construction

With regard to the expressed concerns relating to the stability of the dam and lake during construction, it is normal for the supervising agency to review construction plans and sequencing for adequacy, and the employment of normal engineering practices should not make this a problem.

XI.B.2 CONCERNS REGARDING LACK OF ADEQUATE CONSIDERATION OF ALTERNATIVE MEANS OF HANDLING THE PROBLEMS OF FLOOD CONTROL

For full discussion of Flood Control Alternatives see Chapter XV.

XI.B.2(a) Flood Plain Management

With regard to the matter of flood plain management in lieu of flood control, the conflict of point of view between advocates of the structural (dam) versus non-structural (flood plain management) approaches may be summarized as follows:

Neither dams nor flood plain management prevent floods nor do they preclude flood damage. Flood plain management is a means of reducing the dollar value of the damage which does occur. It cannot protect existing construction in the flood plain. Often it is appropriate to plan for flood control with structural and non-structural means in conjunction with one another.

The structural solution (the dam) or other structural alternatives are more positive, but, usually, more costly solutions. The cost effectiveness of both solutions may be compared by evaluating the different first costs (construction, property acquisition, relocation of existing facilities); and the accruable benefits (higher level of development of the flood plains, multiple use of impoundments). This comparision is summarized in the General Design Memorandum (Sections II and III), in Design Memorandum No. 10, and is discussed in the Environmental Impact Statement. The essence of these analyses is summarized in the following quotation from the Supplement to the Environmental Impact Statement.

> "Flood damage surveys following the flood of 1955 and subsequent surveys of potential damage of 1958 and 1966 and recent reviews reveal that even with the on-going flood proofing, flood zoning and flood insurance programs, there is a positive requirement for the protection of the flood plain along the main stem of the Delaware River. There exists substantial development in the flood plain which

> will be damaged should a high run-off occur similar to those recorded during the past 54 years of record. Much of the flood plain is still developed and unprotected; many communities do not have a flood insurance program and there is always that possibility of loss of life in flood situations.

See Section XI.E.6 regarding flood plain land use.

XI.B.2 (b) Effects of Existing Dams on Mainstem Flood Control

At the 1975 hearings before the Congressional Public Works Subcommittee on Appropriations, the Save the Delaware Coalition suggested that the construction of several dams on tributaries to the Delaware since the 1955 flood have changed the flood control need for the Tocks Island Dam.

With reference to these reservoirs which have been built since the 1955 flood, it should be noted that while having some theoretical impact on mainstem flooding, they are to all practical purposes insignificant in their downstream effect. The total drainage area above Tocks Island Dam is 3,827 square miles. By comparison, the total drainage area above Prompton Reservoir, which contains flood control storage, is only 60 square miles. Similarly, the total drainage area above Jadwin Reservoir is only 64 square miles. These are the only two new reservoirs, other than for minor structures of the SCS Type, which include flood control as a design purpose. The value of these structures is limited to the local channel reaches in the immediate downstream areas. Both of these reservoirs are on tributaries to the Lackawaxen River, which has a total drainage area of 601 square miles and is tributary to the Delaware upstream from Tocks Island. However, the impact on flows at and below Tocks Island of such limited flood control capacity would be negligible.

With reference to Cannonsville, Pepacton, Neversink and Wallenpaupack reservoirs, it should be noted that these reservoirs do not contain flood control storage as a design purpose. They may provide incidental flood control benefits if the conservation storage does not happen to be filled, but the presumption must be made in conjunction with design of flood control reservoirs that such storage is full. In other words, a flood control project must be capable of performing its flood control function up to the intended design level without depending on the coincidental possibility that other reservoirs, which are normally kept as full as hydrologic conditions permit, might just happen to not be full. The incidental flood control benefit which accrues from build up of temporary surcharge storage above a full reservoir also provides limited downstream benefits.

Walter Reservoir on Bear Creek, a tributary of the upper Lehigh River has a drainage area of only 288 square miles. Similarly, Beltzville Reservoir is also on a tributary to the Lehigh River and has a drainage area of only 97 square miles. Since the Lehigh River is tributary to the mainstem of the Delaware below Tocks Island, limited flood control reduction on the mainstem might be attributed to these two reservoirs, but the benefit would only be felt below the confluence of the Lehigh with the mainstem. No benefits would occur between Tocks Island and the Lehigh River. The main purpose of the Walter and Beltzville Reservoirs is for control of floods on the Lehigh River and not for any anticipated impact on the mainstem of the Delaware.

The difference in design concept between flood control reservoirs and conservation reservoirs is basically that flood control reservoirs should be kept empty while the others are kept as full as possible. In the case of a multi-

purpose reservoir involving both water supply and flood control, along with other purposes, such as the Tocks Island Project, the conservation requirements are served by what is generally referred to as the permanent or long-term storage capacity. Flood control requirements are served by storage capacity above the conservation level. This storage is temporary in nature and only holds water during the passage of major floods. In the case of Tocks Island, the conservation pool is at elevation 410 (storage capacity 521,900 acre feet) and the top of the flood control pool is at elevation 432 (845,400 acre feet) resulting in a total flood storage capacity of 323,500 acre feet. The suggestion that the upstream water supply reservoirs, such as Cannonsville and Pepacton might be utilized for flood control purposes thereby alleviating the need for Tocks Island is legally untenable and in contradiction with their purpose. These projects were built and financed for water supply purposes for the City of New York and no flood control purpose is included. Were they to be used for flood control purposes they would have to be emptied or partially emptied in order to provide flood control storage space. This would result in reduced yields for the City of New York, and also reduce the low flow augmentation capability for the lower river.

XI.B.2(c) Use of Several Small Dams Instead of Tocks Island

With regard to the suggestion that flood control be accomplished by construction of a number of small dams on tributaries instead of the single, larger dam on the mainstem, the following is a response from correspondence from the Department of the Army to the District Engineers, dated 16 March 1971.

> During the development of the Delaware River Basin Plan, 386 potential sites in the basin were investigated for

development of small flood control projects. As mentioned previously, 39 of these sites were selected for such development and recommended as part of the basin plan. In reviewing the remaining potential sites, it was found that total flood control storage which could be reasonably developed at all sites (more than 100) studied above Belvidere, New Jersey was less than that of the Tocks Island Lake project. Furthermore, it was found that the small reservoir project sites produced excessive inundation of land per unit of storage as compared to the Tocks Island Project.

In further reference to the utilization of tributary reservoirs, as opposed to a mainstem reservoir, it should be noted that while development of tributary reservoirs might provide the same total flood control capacity as a single mainstem reservoir, a factor of major importance in determining flood control effectiveness is the total amount of drainage area intercepted. Tributary reservoirs, such as Jadwin and Prompton can be highly effective for flood control within the local reaches, but can do little to intercept runoff from major storm patterns of basin-wide extent.

Assuming an equivalent degree of protection for major downstream damage centers could be achieved by small reservoirs, the land use relocation and real estate costs become prohibitive over such a number of different locations. The overall environmental impact would also be considerably greater.

For further discussion of flood control alternatives, see Chapter XV.

XI.B.3 CONCERNS REGARDING ASPECTS OF FLOOD CONTROL WHICH THE PROPOSED PROJECT WILL NOT ACCOMPLISH

XI.B.3(a) Areas not Protected from Floods by Tocks Island Dam

Note has been made of comments to the effect that the proposed project will not mitigate flooding in the reaches of tributaries above the areas of influence of Tocks Island Lake or in the Lower tidal reaches of the river. These statements are correct. It is obviously the purpose of Tocks Island to regulate flood flows generated in the upper basin which will result in reduced flood stages in the mainstem downstream and in the lower reaches of tributaries at their confluence with the Delaware within a limited backwater zone.

Flooding in the lower Tidal reaches cannot be relieved without construction of additional structures in the estuarine section of the river. Study of such additional structures is outside the scope of the proposed project and would, in fact, involve a separate, different project. Mitigating the problem of flooding on the tributaries would require construction of smaller projects on the tributaries to the Delaware River which would be outside the scope of the present, proposed project. Tocks Island, however, is only one part of a major program of flood control in the entire basin with many structural and non-structural projects proposed in the Delaware River Basin Comprehensive Report.

X.I.B.3(b) Harmful Effects of Dams on Floods

There also is concern with the structural (dam) solution based on the belief that dams, by damaging the river regimen, worsen the effects of some floods. The simulation of floods and the affects on structure and surroundings can be determined by generally accepted hydraulic analyses and

such procedures have been employed in preliminary planning. They should be further utilized in the final design phases.

<u>XI.B.3(c) Loss of Life in 1955 Flood was from Flooding of the Tributaries</u>. Another criticism, with reference to the Tocks Island Project, is that the loss of life during the 1955 flood was all on tributaries and that the Tocks Island Dam would not have had any effect on this. This is true, but should in no way detract from the importance of Tocks Island as a flood control project which does effectively regulate floods up to the 1955 level along the mainstem of the Delaware River. In project justification the Corps of Engineers has made no effort to take credit for prevention of loss of life along the mainstem and even on the tributaries this factor has been treated as an intangible which does not enter into the computation of B/C ratios.

It has also been pointed out that a disastrous flood occurred in Cheyenne Basin in 1972 resulting in the loss of 234 lives at Rapid City, South Dakota and this loss of life occurred in spite of the existence of an upstream flood control reservoir. The irony of this tragedy is that the Pactola Reservoir, which is just a few miles upstream from Rapid City, contained 43,000 acre feet of flood control storage which would have been more than sufficient to have contained the entire storm volume, estimated at 10,100 acre feet. The total drainage area above Pactola Reservoir was 292 square miles and this area received almost no precipitation. The 91 square miles of intervening uncontrolled drainage area between Pactola Reservoir and Rapid City received intense rainfall in the range of 10" to 14" within a few hours resulting in a peak discharge of 50,000 cfs at Rapid City in contrast to the previous flood of record some 10 years earlier in the amount of 3,300 cfs.

The nature of conditions in South Dakota and in the Tocks Island region are such that the two situations are not properly comparable. According to Mr. Robert L. Goodell of the DRBC, "There is no record in the flood history of the Basin to indicate that a short duration, intense, but highly confined thunderstorm type precipitation, similar to that which occurred at Rapid City, has produced flood conditions in the main stem of the Delaware River below the Gap. (This is not to indicate that thunderstorm type of precipitation has not produced severe flooding on tributaries of the Delaware River with drainage areas as large as at Rapid City (60 sq. mi.), but these storms have not produced significant flooding in the lower main stem, which is the reach to be protected by the Tocks Island Project)."

XI.C. ELECTRIC POWER CONCERNS

XI.C.1 CONVENTIONAL HYDROELECTRIC AND PUMPED-STORAGE POWER

XI.C.1(a) Power Generated From The Tocks Island Project Should Be Used For DRB Residents and Not Supplied To The General Power Pool of Corporations and Municipal Electric Systems

The power which is planned to be generated in connection with the Tocks Island Lake Project consists primarily of a 1300 MWe pumped storage plant which would provide power during peak demand periods. A much smaller conventional hydroelectric capability (about 40 MWe firm; 70 MWe total) would be developed as a part of the pumped storage project.

The power that is generated by a power plant should be used in the most optimum way to meet the electric requirements of an appropriate service area. The Tocks Island Lake Project allows the development of a significant power generating resource to meet the peak load requirements of both the DRB and certain surrounding areas. Individuals throughout a region receive much greater benefits if the electric power which they use is derived from electrical generating resources which are integrated in such a way as to satisfy the total needs of the region.

XI.C.1(b) What Is The Value of The Kittatinny Project in The Overall Plan For Developing Electric Power in The DRB?

The 1300 MWe Kittatinny Pumped Storage Project will provide needed peaking power capacity. This form of power is needed to supplement the power provided

by nuclear, conventional steam, and hydroelectric plants during time of peak demand. Utilities need an appropriate balance of peaking and base load plants to meet the loads being served.

XI.C.1(c) The Pumped Storage Plant Is The First Type to Lose Power in a Blackout Period

Nuclear, fossil, hydroelectric, and pumped storage plants are all susceptible to being forced out of service during critical electric substation and transmission line failures. There is no apparent reason why the reliability of pumped storage under such failure conditions, which could result in a "blackout period", is any less than for the other types of plants mentioned above. It is true that peak power alternatives, such as gas turbines and combined cycles, can be built in smaller sizes and located throughout the service area, thereby significantly reducing their loss of power as a result of major substation and transmission line failures.

XI.C.1(d) Would The Use Of Pumped Storage Facilities in The Overall Generation Mix Tend to Reduce Air Pollution Potential?

Yes. Pumped storage generation requires more energy for pumping water to upper reservoirs than is generated in its turbine; however, its use does tend to reduce the total air pollution. The reason for this is that pumped storage generation is used for peaking requirements, avoiding the necessity for using fossil thermal plants of relatively low efficiency, which could be used for this purpose. Emissions to the atmosphere from use of the less efficient thermal plants is then eliminated. Furthermore, while most of the energy for pumping water to upper reservoirs would initially be provided by fossil fuel base load plants, the pumping energy provided by nuclear plants would start becoming significant in the early 1990's. As nuclear plants provide a greater share of

pumping energy, air pollution decreases in proportion.

XI.C.1(e) Pumped Storage Is Not The Best Method For Generating Electricity To Supply Peaking Demands. It Requires 3 KWHs of Energy To Generate 2 KWHs.

Thermal-electric plants will carry the major part of the region's base load capacity, but are an expensive source of peaking power. To supplement base load plants in meeting future peak power demands, pumped storage, gas turbines, and combined cycles are the alternatives presently available on a commercial basis. The three alternatives are compared in Chapter XIV, Electric Power Alternatives.

Pumped storage hydro is unique among methods of power generation in that it is dependent on other electrical power sources for its energy supply. It accumulates low-valued off-peak energy generated at thermal electric or other conventional power plants by pumping water from a lower to a higher reservoir. The stored water can then be returned through turbines to generate power during peak load periods, when it is most needed and has its greatest value. Pumped storage facilities offer many advantages:

1. rapid start up
2. long life
3. dependability
4. low operating and maintenance costs
5. adapability as low-cost spinning reserve

Although a pumped storage plant uses more energy than it generates, the intent is to eventually use low cost off-peak nuclear energy for pumping so that fossil

fuels are conserved. Gas turbines and combined cycle plants, which are alternatives to pumped storage, have a greater overall energy utilization efficiency than a pumped storage plant, but require the use of rapidly diminishing fossil fuel resources and have higher operating costs.

XI.C.1(f) Will There Be Any Effect on Sunfish Pond?

Results of detailed studies indicate that the reservoir and its expansion have not caused and will not cause any significant impairment of Sunfish Pond and its recreational, educational and ecological values - provided safeguards are employed.

The expanded reservoir would occupy about 17% of the pond's watershed; however, this will not significantly alter the natural pond water level dynamics. Water level fluctuations of 3 to 4 feet occurred during the 1960's drought, and the flucuation in 1971 was about one foot. A study of moderately low flow conditions indicated that the watershed loss will affect the pond by only a few inches. The possibility of some seepage from the reservoir exists, but this can be corrected by application of engineering technology.

XI.C.1(g) The Installation of Tunnels, Transmission Lines, Etc., Will Denude The Area of Route

The text below answers the aforementioned concern, and was taken from the "Third Amendment and Supplement to Application Approved August 1962, DRBC Docket # D-62-2, for Approval of Kittatinny Mountain Project" by the Jersey Central Power & Light Company and the New Jersey Power & Light Company and Public Service Electric and Gas Company, dated March 1971.

"The Kittatinny Mountain Project will involve various underground facilities, consisting of (1) a pumping and generating station, (2) a series of large water passages connecting that station with the Delaware River Tocks Island Dam, (3) an access tunnel and an access shaft, and (4) underground transmission lines on the western side and top of Kittatinny Mountain. The pumping and generating station, the water passages, and the access tunnel will not only be underground but will be constructed by tunneling. The environmental impact thereof will therefore be confined to the disposal of spoil, ground water effects, possible subsidence and the appearance of the portals."

XI.C.2 ELECTRIC POWER DEMAND

XI.C.2(a) Electric Utilities Overestimate Power Demand

The utilities have generally assumed in recent forecasts that power demand growth will be similar to that which occurred over the last 10 to 15 years. Many investigators have recently challenged this basic assumption and have concluded that the growth rate will be much less. During the past year, many changes have occurred which relate to the requirements for electric power. Chapter V of this report examines power demand forecasting in some detail, and compares utility forecasts with "probable high" and "probable low" forecasts developed in this chapter.

XI.C.2(b) Peak Load Pricing Should Be Used

Peak load pricing has been shown in many studies to have a definite effect in lowering electrical demand, but there still remains some uncertainty as to the degree of reduction which would be achieved. The analyses of Chapter V on electric power deal with the question of power demand and provide several analyses of demand reduction which could be achieved if peak load pricing is put into effect.

XI.C.2(c) Energy Conservation Should Be Considered

Energy conservation measures could have significant effects in reducing demand. Improving appliance efficiencies, using good insulation and weather proofing techniques, reducing lighting requirements, constructing low energy use building, and other measures, will be effective in reducing future demand if state and federal regulations are established and enforced in order to implement such measures. The effects of energy conservation on demand are also discussed in Chapter V, which deals with electric power.

XI.C.3 WATER DEMAND BY POWER PLANTS

XI.C.3(a) Electric Power and Water Supply Should Be Considered Together

The generation of electrical power has an important effect on water consumption, and the relationship between power generation needs to be quantitatively examined. Water is used in many ways to provide important benefits to people: homes, for recreation, and in many different industrial plants which produce the goods we all use. Electric power is also an extremely important benefit, and some water must be consumed in the process of generating the quantities of power that we use today and that will be used in the future. Estimates of the water needed by future power plants are made in Chapter V for several alternative situations.

XI.C.3(b) Past Water Demands Should Not Be Used To Forecast Future Demand of Water For Power Plants

In Chapter V, future power plant water consumption is being forecasted by evaluating future power demand, the types of plants used to meet demand, and

the locations of these plants. It is true that future power plant water demand cannot be determined by extrapolating past demand.

XI.C.4 FOSSIL AND NUCLEAR POWER PLANTS

XI.C.4(a) Private Development of a Fossil-Fueled Plant On The Coast Would Serve The Same Load as TILP

A fossil-fuel base load power plant is a plant which has been built to operate a significant portion of the time in order to satisfy the constant portion of the electric load in an area. On the other hand, a peaking plant, such as the 1300 MWe Kittatinny Mountain Project, has been designed to be operated over only a part of a day in order to assist in meeting the peak load which occurs during the day. A fossil-fuel base load plant, if operated to only supply peak load, would be very uneconomical and would cause higher rates by the people using that power.

XI.C.4(b) The DRB May Be Entirely Too Heavily Populated For Nuclear Siting. Look Into Coastal Locations.

Siting alternatives for the future power plant resource mix are investigated in Chapter V, Electric Power. The potential for coastal and offshore siting is evaluated.

XI.C.4(c) Limerick Generating Station Does Not Have a Cooling Water Source

This topic was reviewed in the Limerick construction permit hearings by the AEC regarding an adequate cooling water source. The current plan is to draw consumptive make-up water, during low Schuylkill River flows, from the Delaware River. The source of such water starts at the Point Pleasant

diversion that transfers the water to the Perkiomen Creek through a pipeline. This pipeline would be in conjunction with a municipal water supply system for Bucks County, and would be linked with a reservoir in the Neshaminy Creek. Philadelphia Electric has been working with the county in the design of the pumping station and the pipeline.

The Limerick station water would then come from a branch in the pipeline to the Perkiomen Creek and would be taken out at a pumping point near the town of Graterford through a pipeline on a transmission right-of-way. The environmental report for the Limerick station described the system from the Perkiomen to the Limerick station. The environmental report for Buck's County system application described the pumping station in the Delaware, the pipeline, and the water flow down the Perkiomen.

In the DRBC authorization to pump water from the Delaware, was a statement to the effect, in paraphrased form, that if by 1977 in the DRBC's opinion there is not enough water storage available in the Delaware for the Limerick station make-up water supply, Philadelphia Electric would provide their own reservoir to meet the Limerick needs. There have been reservoir siting studies performed, and several potential locations have been described to the DRBC.

For discussion of water required for power plant cooling, see Chapter V.

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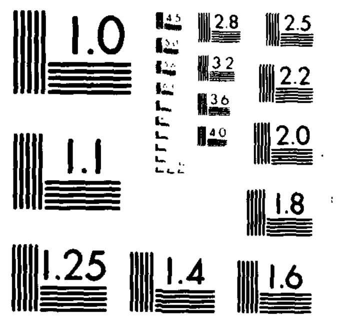

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XI.C.4(d) It Is Understood That The Orange and Rockland Electric Company Is Planning to Build a Nuclear Power Plant, Called Cliff Station, Above The Tocks Island Lake Project. If This Plant Is Built, The Radioactive Wastewater Will Be Going Into a Still Reservoir, Contaminating It.

The report to DRBC, "Major Electric Generating Projects 1974-1988," Delaware River Basin, dated May 1974, describes a proposed Cliff Nuclear Generating Station to be located between Cliff Lake and Swinging Bridge reservoirs in the Mongaup River drainage area. The Mongaup River combines with the Delaware River above the proposed Tocks Island Lake Project.

The potential radionuclide effluents from nuclear stations, such as Cliff Nuclear Generating Station, will be considered in accordance with EPA and NRC regulations should future applications be submitted. Appropriate studies in the assessment of this expressed concern would be undertaken, as required, at such time.

XI.C.4(e) Beneficial Uses Should Be Made Of Waste Heat From Generating Stations in The DRB

The electric utility industry has been conducting experiments in a number of areas related to the beneficial use of waste heat from power generation. There are several types of beneficial uses which are possible. These include various aquaculture and agricultural applications, using the warm water to assist in sanitary waste water treatment, and the integrated use of the warm water for new communities. The heat that comes from power plants in the cooling water is of relatively low grade, because the temperature difference between the heated water and the natural environment is generally between 10 and 25 degrees Fahrenheit. Since the temperature difference is so low, large quantities of water are used to remove the

heat from the condensers, and the projects which are underway or completed have been only able to use some fraction of the warm effluent. Thus a significant portion must still be disposed of, either through a once-through cooling system or through the use of cooling towers. In terms of aquaculture, the artificial addition of heat can have beneficial effects in a number of ways. Accelerated growth rates have resulted in the development of fin fish, shrimp, lobsters, oysters and other organisms which can be farmed in thermally enhanced environments. Studies have shown, for example, that the normal seven year time of maturity for lobsters can be reduced to two or three years in warm water. In terms of agricultural uses of waste heat, experiments and projects have been developed to control crop humidity and temperature conditions by warm water irrigation, soil warming and greenhouse heating and air conditioning. There have been several important projects that have extensively investigated the use of warm water in agriculture. One of the chief ones is the U.S. Environmental Protection Agency's sponsorship of a project in Oregon.

A number of utilities across the country produce both electricity and steam for sale. An important concept that is gaining increased attention is to think of a nuclear plant as an energy center, with the products of the center serving both the electrical energy and heat requirements of local residences and businesses. Energy centers offer the potential for optimal utilization and conservation of energy resources. However, the factors which must be considered in this are trade-offs between the value of steam as a heat source and as an energy source for electrical power.

In terms of specific applications of such beneficial uses within the electric service area, several utilities have studies underway. Pennsylvania Power and Light, Philadelphia Electric, and others are planning a three year aquaculture project on the Susquehanna River at the Brunner Island Steam Electric Station. Franklin Institute of Philadelphia will participate. Public Service Electric and Gas is carrying out an experimental trout farming project, and has completed an experiment to harvest shrimp.

XI.C.5 ALTERNATIVES

Is the gas turbine more efficient than the pumped storage facility for generating electricity?

A pumped storage facility requires about 1.5 times as much energy to pump water to the storage reservoirs as is retrieved when generating electricity. It takes about 10,500 Btu of heat energy to generate one KWH of electricity at a nuclear power plant. Therefore, generation of one KWH of pumped storage electricity during peak demand requires about 15,000 Btu of energy. A gas turbine plant using fossil fuels requires about 12,000 to 14,000 Btu to generate one KWH of electricity.

Therefore, a pumped storage plant is a little less efficient than a gas turbine in terms of unit electrical output per unit fuel input. However, the pumped storage plant, which uses efficient baseload energy for pumping, can usually produce electricity at less cost than gas turbines. This question will be discussed further in Chapter XIV, Electric Power Alternatives.

XI.D. ECONOMIC CONCERNS

The local governments of Sussex, Warren, and Hunterdon counties, New Jersey, and of Pike and Monroe counties, Pennsylvania, have expressed concerns for the Tocks Island project because of its potential economic impact on the basic governmental services which they are responsible for providing. Several jurisdictions within these counties have had land purchased by the federal government for the Tocks Island project, which has resulted in a concern for loss of tax base and ratables. (For discussion of tax base see Chapter XXII.C.2.(i).) Additionally, individual residents have had to sell their homes and farms and they expressed concern for their personal financial situations.

XI.D.1. IMPACT ON PRIMARY AREA SERVICES

Elected and planning officials, local citizen organizations and individuals of the primary impact counties have expressed concern for the prospect of four million or more people visiting the Delaware Water Gap National Recreation Area annually. These visitors will travel through their jurisdictions, create traffic jams, deposit litter, and make use of county services. Leaders within the primary impact counties assess their basic services as barely able to meet the needs of permanent residents and insufficient to meet the anticipated demand of an influx of visitors. Areas of concern regarding highway maintenance, police and fire protection, emergency medical

services, solid waste disposal, water supply and sewerage systems are discussed in Chapter XXII.C.4. Traffic problems are the subject of Chapter XXV. Schools are discussed below.

The topic of schools has two levels of concern. First, Park Service personnel currently living on government property send their children to local schools without paying property taxes. Some permanent residents, whose property has been acquired, have exercised their tenancy rights to remain on park lands and though no longer on tax rolls, continue to use the schools and other municipal services. This point is frequently made by local officials to illustrate how area taxpayers are subsidizing the Tocks Island project. A second concern is that DWGNRA will spur general development which will result in an increase in school age population. This concern, which is much more important over the long run, is not mentioned as frequently. It should be viewed as a "secondary impact" as visitors discover the area, buy land, and build homes.

Local officials have requested that the first concern be mitigated by federal payments to local jurisdictions as a reimbursement for per capita student costs. The town of Sandyston, particularly hard hit by this problem, has received emergency funds from the State of New Jersey. None of the townships, so far, have received Title I Federal funds under the provisions of the Elementary and Secondary Education Act of 1965 for federally impacted areas. Left unattended, this fiscal inequity would undoubtedly worsen

as time passes if the families of more Park Service personnel as well as construction workers reside on government owned land. The second concern--provision of schools for future permanent residents attracted by DWGNRA--must be considered against the backdrop of the New Jersey tax structure, which places the burden for school financing squarely on local jurisdictions. It is estimated that the type of development--single-family homes--and the resultant tax yield likely to occur in the impacted area will be strained to support an expansion of the public school system.

XI.D.2. FISCAL IMPACT ON PRIMARY AREA GOVERNMENTAL JURISDICTIONS

In addition to the concerns pertaining to increased costs associated with expansion of basic governmental (and private) facilities and services, more direct concerns relating to fiscal impacts include:

XI.D.2(a) Loss of Tax Ratables

The loss of tax ratables is due to the federal acquisition of private property for the Tocks Island Lake and the National Recreation Area. Jurisdictions affected are those which were partly in the project area. Concern is expressed by local officials as to whether or not federal payments will be forthcoming to municipal government to replace lost tax revenues. The town of Sandyston, for example, feels that the DRBC has the responsibility to replace these ratables and refers to the DRBC Compact:

"14.3 Tax Exemption. . . . in lieu of property taxes the commission shall, as to specific projects, make payments to local taxing districts in annual amounts which shall equal the taxes lawfully assessed upon property for the tax year next prior to its acquisition by the commission for a period of ten years."

The taking of private land for a public purpose is an unavoidable consequence of the Tocks Island project. The focus of local concern is not so much that land has been taken (this is a common practice in our political system) but that land which once produced tax revenues has been taken. If the affected jurisdictions are not compensated, local officials have stated that a heavier tax burden rests on the remaining land.

XI.D.2(b) Tax Base Loss and Increased Demands for Local Governmental Services

Local officials are concerned that an increase in demand for governmental services will result when additional people visit their areas. Ironically these increased demands will have to be served by a shrinking tax base (the most impacted jurisdictions include two municipalities in Monroe County, Pennsylvania, two in Sussex County New Jersey, and one in Warren County, New Jersey) brought on by the acquisition of private property for the Tocks Island project. To ameliorate these losses in tax base, offsetting growth along with increased land values and tax rates will result in increased revenues.

Local officials have concluded that the increased demand for local governmental services is an unavoidable consequence of the project. Officials

have indicated their intent to seek resources from the state and federal governments to assist them in providing for increased service demands made by visitors.

XI.D.3. FINANCIAL IMPACT ON LOCAL RESIDENTS

Recorded testimonies state that local residents have been affected directly and personally by the Tocks Island project through the loss of their homes and the breaking-up of their communities.

There has been considerable testimony that hundreds of property owners have lost their homes or will have been displaced due to the government purchase of private property. It has been alleged that some property owners have not been paid the full value for their properties. As a direct result of government land acquisition, speculation has increased the purchase price of land which has resulted in a financial hardship for persons seeking to relocate within the area. Further, it has been stated that the project time-lag has added to the residents' uncertainty relative to moving. These alleged losses have been absorbed and are being absorbed personally by the property owners who happen by chance to live in the project area.

There is no apparent recourse for those property owners who feel, in retrospect, that they received less than a fair market price for their properties. Executed contracts are difficult, if not impossible to reconsider.

Nevertheless, individuals and families have expressed concern over having sustained what they consider to be personal financial losses. For further discussion of land acquisition, see Section XI.E.1. of this Chapter.

XI.E. LAND USE CONCERNS

XI.E.1. LAND ACQUISITION PRACTICES

The Tocks Island Lake Project and The Delaware Water Gap National Recreation Area as authorized by Congress, required the acquisition of considerable acreage along both sides of the Delaware River from the Delaware Water Gap up to Matamoras and Port Jervis.

At the present time, the Corps Real Estate Office in Stroudsburg plans to or already has purchased 2,700 tracts comprising 25,290 acres for the Tocks Island Lake Project and 4,500 tracts comprising 44,400 acres for the Delaware Water Gap National Recreation Area. Of the total of 69,690 acres, 47,869 are already acquired. Acquisition as of April 30, 1975 is 68.7 percent complete, at a cost of $97,093,855.[1]

Over the thirteen years since the Dam was first authorized, a number of criticisms have been raised concerning the procedures by which this land has been acquired. Senator Wayne Dumont, representing the 15th State Senate District of New Jersey (Passaic, Warren and Sussex Counties) called the land acquisition practices "deplorable."[2] In the hearings before the Public Works Subcommittee of the Committee on Appropriations, House of Representatives, 93rd Congress 1975, Ms. Mina Haefele claimed that "it would appear that gross favoritism, underhanded threats, misleading information and petty discrimination ... have been used to demoralize the property owner and to drive down the price on their properties".

(Note: Sources are noted on Page XI-73)

Some of the criticisms have dealt with specific hardship cases, other have been concerned with extensive time delays, uncertainties, upheavals of personal lives, especially of the elderly, and of profits reaped by some land speculators. This study is not concerned with a detailed analysis of these specific cases, but the information which follows attempts to further describe the land acquisition situation.

The Tocks Island Project was authorized in the Flood Control Act of 1962 (PL87-874), the Delaware Water Gap National Recreation Area in 1965 by PL89-158. Both of the Congressional actions established the basis for land acquisition, however actual funds were appropriated on a piecemeal basis over a number of fiscal years.

The fact that land was to be acquired was known, then, by 1962, but land purchase did not begin until 1966. A tentative schedule was established by the Corps, moving sequentially from the dam upriver:

Delaware Water Gap to Tocks Island -- Fiscal Year (FY) 1966

to Bushkill -- FY 1967

to 5 miles south of Dingman's Ferry -- FY 1968

to Dingman's Ferry -- FY 1969

to 3 miles south of Milford -- FY 1970

to Milford by June 30, 1972 [3]

At that time, acquisition procedures were followed in accordance with PL86-645, River and Harbor Act of 1960: Sec 301 "It is hearby declared to be the policy of Congress that owners and tenants whose property is acquired for public works projects of the United States of America shall be paid a just and reasonable consideration therefore..." Sec. 302 "Within six months after the date that Congress authorizes construction of a water resource development project

under the jurisdiction of the Secretary of the Army, the Corps of Engineers shall make reasonable effort to advise owners and occupants in and adjacent to the project area as to probable timing for the acquisition of lands for the project...."

Property appraisals were prepared for the Corps by real estate consultants and Corps staff. The "appraisers will attempt to estimate the fair market value of the property -- the price it would be sold for in a private transaction between two individuals...(the appraiser will) appraise the property at the highest price he thinks it would have sold at had the project not been authorized."[4]

Land and improvement values for specific types of properties were prepared by study of comparable real estate transactions in the area and are contained in the Corps of Engineers "Real Estate Design Memoranda" related to each project.[5]

As of 1975, as already indicated, only 66% of the property has been acquired. Some of the delays in appropriation of funds may have been attributable to the pressures on appropriations brought about by the war in Vietnam.[6] Other delays have been due to the continued controversy surrounding the project, thus limiting the Congressional appropriations each year. In addition, land acquisition funds for each project (Tocks Island Lake Project and The Delaware Water Gap National Recreation Area) were separately authorized and could not be co-mingled, although the Corps wished to do so in an effort to proceed on a more orderly basis, especially as regarded split-tracts (properties which fell partly into each project).

The effects of these institutional problems (lack of a more effective, smooth flowing funding procedure to expedite land purchase) was to witness more than

a decade of fast rising property values.

Tables 11-4. Comparison of Real Estate Costs Per Acre

	Original Gross Est. Cost/Acre	Real Estate Design Memos Cost/Acre	Acquisition Cost, 1974 Cost/Acre
T.I.L.P.	$1,549 (3/65)	$1,718 (1/72)	$2,492 (10/74)
DWGNRA	$ 673 (11/64)	$ 766 (7/69)	1,531 (10/74)

Costs include land and improvements
Data provided by Army Corps of Engineers, Real Estate Division, New York

This upward pressure on land values was due in part to the existence of the planned projects and in part due to the general demand for recreational and second home properties this close to the New York and Philadelphia metropolitan regions.

The Real Estate firm of Jackson-Cross of Philadelphia has done acquisition cost estimates for the Corps. In 1971 they updated their earlier work. In that report they made the following observations: "The increase in the estimated cost of acquiring this property while definitely indicated by the market data studied...is inherent in the piecemeal acquisition of large assemblies of property."

"We see very little evidence that prices here are escalating merely because of the taking itself."[7]

This has led to seeming inequities between those who sold their properties in the early years and those who are still to sell, though the consequences were inevitable given the funding and time period constraints of the project circumstances.

Over the years there have also been some serious problems with land speculation, which led to specific efforts to contain these forces by the Secretary of the Interior, the President of the United States and local utility companies and the Tocks Island Regional Advisory Council.[8]

For these and perhaps other reasons, the original pattern of logical land purchase has not followed the simple geographic sequence. Some development properties, as yet unsubdivided, were among the first purchased to prevent further land speculation sales.[9] In other cases, the Corps agree to early purchase of some hardship cases.[10]

A patchwork pattern developed which had the effect of spreading out the takings over widespread areas. "As the U.S. Government buys land and indicates those areas in which it will purchase land in the future, some of the adhesive which holds a community together begins to dissolve."[11] The tendency for these properties to become vandalized has added to the pressures on those still remaining to hasten their departure.

When property owners and the Corps did not agree on price, the judicial procedures of condemnation were followed. According to some critics, no effort was made to expedite the court cases, and property owners experienced extended delays in obtaining money,[12] though the full appraisal value is deposited with the court and may be withdrawn by the owners upon proof of title. Promises regarding advance notice and/or timing of acquisition have not always been honored.[13]

On a number of occasions the Un ited States General Accounting Office has been requested to investigate these proceedings. According to an article in the

New Jersey <u>Herald</u> of May 11, 1975, the most recent report prepared for former New Jersey Congressman Joseph Maraziti cleared the Corps of Engineers of wrongdoing. The newspaper also indicated that Mr. Maraziti and the Four County Task Force remained unsatisfied with the results.

Some of the earlier complaints about procedures have been mitigated in later dealings because of the more specific benefits and assistance now available under the provisions of Public Law 91-646, the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970" which became effective on January 2, 1971.

The Army Corps of Engineers has available an "Information Brochure Concerning Public Law 91-646" which clearly describes the relocation advisory assistance available under this act including information on funding "<u>comparable</u>, decent, safe and sanitary replacement housing and comparable commercial properties and farms."

The problem of higher costs of replacement homes for those retired on fixed incomes has increased the difficulties for this segment of the population. The provisions of the current legislation provide some means of assistance in this regard.

In the recent Princeton Studies on the Tocks Island Project, Robert Socolow remarked that "some of the people who have had to sell to the Corps are bitter about the procedures by which these sales have been accomplished, and they are persuasive when they argue that there are not enough built-in safe-

guards to protect them."[14]

Many former landowners feel that they have been well treated in their experience with the Corps of Engineers. According to the Corps Real Estate Office, over 90 percent of the acquisition transactions were accomplished through mutual agreement and less than 10 percent have required eminent domain proceedings.

Property owners can be expected to show some degree of resistance or unhappiness at the prospect of having to sell their property if they had not been otherwise planning to do so. Under these circumstances it is likely that certain of them will never be satisfied with the resulting experience.

It is true that the dissatisfied residents who remain in the area have added to the ranks of the local opposition. Further examination of government procedures, property acquisition funding methods, and acquisition scheduling should be undertaken to continue to minimize problems and property owner dissatisfaction related to land-taking procedures.

1. Gordon Dilley, U.S. Army Corps of Engineers, Philadelphia.

2. Delaware River Basin Commission Hearings, November 18, 1974, p.160 of Manuscript.

3. Newark Star Ledger, July 27, 1966.

4. ibid.

5. Real Estate Design Memorandum #4, Tocks Island Reservoir Project, Corps of Engineers, North Atlantic Division, Philadelphia, Pa., August, 1967.
REDM #4A - March, 1970
REDM #4B - June 1971
REDM #1 - DWGNRA, March 1966
REDM #1A - DWGNRA, February, 1967

6. Newark Evening News, March 17, 1966

7. John P. Dolman, M.A.I., Acquisition Cost Estimate Recreation Land Adjoining Tocks Island Reservoir, Jackson-Cross Co., May 14, 1971

8. Tocks Island Regional Advisory Council, Brief on Land Speculation Issue, T.I.L.P. and DWGNRA, July 8, 1971.

9. Blue Mountain Lakes and Skyline Acres, Walpack, N.J. and Hidden Lakes, Middle Smithfield, Pa. -- Evening Times, Trenton, N.J., July 26, 1966.

10. Interview with Mr. George Weinstein, Real Estate Division, U.S. Army Corps of Engineers, 90 Church Street, New York, N.Y.

11. Snyder, Eric K., DWGNRA Impact on Sussex County, N.J., October 17, 1973.

12. Senator Wayne Dumont, New Jersey, telcon, February 7, 1975.

13. Colonel Daniel Sullivan, Pike Co, telcon, February 7, 1975, re: Dingman's Falls Park.

14. Socolow, Robert H., Failures of Discourse: Obstacles to the Integration of Environmental Values into Natural Resource Policy. A Reading of the Controversy Surrounding the Proposed Tocks Island Dam on the Delaware River, Report No. 12(b), November, 1974.

XI.E.2 PRESENT USE DISLOCATIONS

The 72,200 acres now being acquired for Tocks Island Lake and the DWGNRA were lands used for farming, permanent and summer homes, summer camps, woodland, some commercial facilities and summer resorts. Critics have objected to the usurpation of some of these functions by the lake and the National Recreation Area. This section will deal with some of these concerns.

A listing of types of properties acquired can be developed from the Jackson-Cross gross estimates and Corps of Engineers Real Estate Design Memoranda and has been summarized in Table 11-6.

In the most recent hearings before the House of Representatives Public Works Subcommittee of the Committee on Appropriations, the Corps of Engineers lists the following breakdown:[1]

Table 11-5. Breakdown of Land Acquisition by Property Type--1975

Residential:	2,622 units
Farm:	125 units
Commercial:	214 units
Public Buildings:	61 units

A reading of the Real Estate Design Memoranda gives a general descriptive picture of the area as viewed by the Corps:

T.I.L.P.

"Typical river valley land with level farmland on the Pennsylvania side and rolling land on the New Jersey side. The active farming areas are generally

(Note: Sources are noted on Page XI-86)

Table 11-6. Breakdown of Land Acquisition by Property Types According to Realestate Design Memoranda and Gross Estimates

	YEAR ROUND RESIDENCES	SEASONAL DWELLINGS	FARMS	SUMMER CAMPS	RESORTS	COMMERCIAL	OTHERS
REDM #4 Aug. 1967 T.I.L.P	276	385	35	10	9	33	Fernwood Bushkill Falls Lodge 10 Special Purpose 9 Miscellaneous
REDM #4A March, 1970 T.I.L.P	232	213	15	-	2	7	Raymondskill Falls 1 School (Dingman's Ferry) 2 Churches Dingman's Ferry Volunteer Fire Department
REDM #4B June, 1971 Portion of Relocated U.S. 209 T.I.L.P.	17	9	Misc. Agric. Bldgs.	-	-	2	1 Township Hall 1 Recreation Hall 1 Dormitory 1 Sawmill
REDM #4C Current draft (1975) T.I.L.P.	37	21	2	-	2	2	
Jackson-Cross Gross Est. DWGNRA 1964	375	768	36	7	8	-	5 Motels 3 Summer Hotels 19 Miscellaneous 4 Estates 3 Churches 3 Country Clubs 1 Grange Hall
TOTAL	937 units	1,396 units	88 units	17 units	21 units	44 units	

confined to the Pennsylvania side of the river.

...the land within the project is approximately 65% cleared. The soils are well-developed and there are areas of very good farmland.

...much of the river frontage has been converted into recreational lots and seasonal developments."

REDM #4
August 1967

D.W.G.N.R.A.

"In describing the present use of the project, there are two factors prevailing in the general area. The first is the boom in recreation and second homes for summer and seasonal use. This has led to the expansion of several developments and the purchase and occupancy of vacant farms and residences by vacationing groups and families. The second factor affecting land use is the decline in farming in the area with the result that land actually cultivated or grazed is a minimal percentage of the total project area. The majority of the land is idle and serves only for hunting and recreation."

REDM. #1
March 1966

XI.E.2(a) Residences

As the preceding tabulations show, approximately 2,421 to 2,622 residences have been or will be dislocated by the combined project. The Corps uses an average of four persons per household and at that rate, approximately 9,684 to 12,488 people have been disturbed. According to recent U.S. Census materials, a figure of 3 to 3.5 per household is more realistic. At 3, the number of people affected would be reduced to 7,263 to 7,866.

Given the fact that these projects have been authorized within specific boundaries, the displacement of these residences is an unavoidable consequence. For those residents whose properties would be within the boundaries of the lake, relocation was mandatory; for those within the confines of the National Recreation Area, PL 89-158 included some provisions for residents to remain under certain circumstances:

"Sec. 2(d). "The beneficial owner, not being a corporation, of a freehold interest acquired before January 1, 1965 ... may retain a right of use and occupancy of such property for non-commercial residential purposes for ... either (i) a period terminating upon his death or the death of his spouse, whichever occurs later, or (ii) a term of not more than twenty-five years."

Of the total number of misplaced property owners, year-round and farm residences made up only approximately 42%, the remaining being summer or second home owners. Of the same total, only approximately 25% were within the boundaries of the T.I.L.P.

According to local residents, the summer owners were not seriously affected since most were able to make other arrangements, either in the region or elsewhere, for summer homes. As previously mentioned, the greatest hardship among permanent residents dislocated, fell among the elderly and lifelong residents whose lifestyles were least adaptable to enforced change.

Where tenants are remaining in lease-back arrangements with the National Park Service, the residents become a tax burden upon the local communities who must continue to provide services and schools for these people who are no longer paying taxes. This subject has also been treated in the preceding Chapter XI.D.

XI.E.2(b) Summer Camps

Criticism has been raised regarding the fact that a number of summer camps were acquired and thus disrupted for the combined projects. The table lists 17 camps, which also corresponds to the recollections of Mr. William Bramhall, formerly of the Army Corps Real Estate Office in Stroudsburg and now with the National Park Service in Denver. He indicated that of these camps, six were Boy Scout Camps in New Jersey, two were Girl Scout Camps - one on each side of the river, 4 or 5 were church affiliated camps, 1 was a YMCA camp and 3 or 4 were commercial camps.[2]

One aspect of the criticism regarding the taking of these camps involved the fact that inner city children used these camps. Their families, the argument went, would not have the resources to drive them to outings in the Delaware Water Gap National Recreation Area and it was implied that continued use of these or other camps would not be available.

In an effort to evaluate this situation, the six Boy Scout Camps were investigated as a representative example of what the results actually were of these camps having been acquired. Information regarding the Boy Scout Camps was obtained by a series of telephone conversations with the respective council leaders.

CAMP WEYGADT - This camp was the first to be acquired. Its properties were just south of the Delaware River Gap and the camp now houses the headquarters of the National Recreation Area. Camp Weygadt belonged to the Easton Pennsylvania Boy Scout Council. That Council has merged with the Councils of Allentown and Bethlehem, Pennsylvania, each of which had its own camp further west in the Poconos. Three camps were not required for the merged Council. The money received for Camp Weygadt has been placed in trust, and the return is being used for the upkeep and preservation of the other two facilities.[3]

CAMP PAHAQUARRA - Camp Pahaquarra, located in Pahaquarry Township, was acquired from the George Washington Council of Trenton, New Jersey. This council replaced its facility in the same region by purchasing property and building a new camp in Blairston on Yards Creek just over Kittatinny Mountain.

They are pleased to have a new facility, but they have incurred a considerable debt since the new camp cost more than they received from the Army. The process of fund raising required to develop the new camp was a cause of much dissension within their organization and a great strain on their volunteer support.[4]

CAMP NO-BE-BOS-CO - This camp is located in Hardwick Township and their property adjoins the boundaries of the Recreation Area. The camp center is located on Sand Pond. As a protective buffer against future development, the camp also owned property on the steep Kittatinny mountainside. It was this surplus property that was sold to the Corps of Engineers. The Recreation Area keeps the adjacent lands in natural woodland and the sale provided the Bergen New Jersey Council with surplus funds to make improvements to their existing facilities. This Council also owns a camp in the Adirondacks to supplement their capacity.

CAMP KEN-ETIWA-PEC - The Orange-Mountain Council camp was located in Walpack and was acquired for approximately $650,000 by the Corps. This Council has since purchased property in the Adirondacks and built a new camp whose total costs have amounted to approximately $1,350,000. As with the George Washington Council, the fund raising effort was divisive and it left them with a $400,000 debt. They,too, have a new and better facility, but at a distance which precludes the all-year-round weekend outings they had previously been able to make. Provision of overnight group camping in the DWGNRA would solve this problem for them.[6] The campsite, on Long Pine Pond is currently being used by the New York State Urban League on a lease arrangement, where 300 to 500 children come for two-week summer sessions.

CAMP COWAW - Camp Cowaw belonged to the Raritan New Jersey Council. It was located on a hilly and relatively unsuitable site in Pahaquarry Township. This Council has merged with another Jersey Council to form the Thomas A. Edison Council. The merger partner already owned another camp in property

surrounded by Stokes State Forest and this camp, which is on a better camping site, is used by the enlarged council.[7]

CAMP MOHICAN - The Newark-Robert Treat Council owned Camp Mohican located in Blairston on Catfish Pond. The Corps has only recently acquired this property and the Newark camp will be operating as usual this summer within the allowed one-year time period to relinquish the premises. The Council is planning to request an extension to remain at least through the 1976 summer season. The National Park Service has invited the Newark Council to make a proposal to them for continued management of the camp within the recreation area.[8]

In all cases reviewed above, the scout councils have made other arrangements to continue providing group camping recreation experience. No youngsters have been deprived as a result of these land acquisitions.
National Park Service leasing program, at this time existing facilities are already utilized to widen the exposure of city children to camping.

The hardships of two scout councils came from the high replacement cost of other campgrounds. If the Newark Council is forced to follow suit, the problem will be aggravated. If,on the other hand, they are accommodated within the DWGNRA, they and many other groups will continue to have access to group camping in a greatly enhanced and preserved natural environment.

XI.E.2(c) Agriculture

Mrs. Joan Matheson of the Delaware Valley Conservation Association has argued that "105 farms will be drowned for the Tocks Island Dam. The fallow ground, which is growing richer every year, is more precious."[9] Others, too, have criticized taking of valuable farmland for a lake and recreation area.

One question to be addressed here is whether or not there were viable farms operating prior to the advent of the Tocks Island Lake Project and, if there were, could they have been expected to remain as farms if the land had not been acquired.

Tables 11-2 and 11-3 indicate 88 to 125 farm properties were involved. There is no question that many of them were on fine bottom land along the banks of both sides of the river. An inquiry of agricultural officials in the four counties was made to determine the nature of these farms.

MONROE COUNTY--According to Department of Agriculture Land Capability classification, the farm land along the river is suitable for cultivation with little or no conservation required. It is considered excellent for corn and alfalfa cash crops. Three successfully operating dairy farms were purchased.[10]

PIKE COUNTY--The farm land to be inundated in Pike County is by far the best farming land in the county. There is no question that it is top quality farmland, superb for growing corn. Some is being farmed now on a lease arrangement.[11]

WARREN COUNTY--There is little farmland of any significance within the taking area in Warren County. Some small tracts just north of the Worthington property were farmland but they have had only limited use for a number of years.[12]

SUSSEX COUNTY--Farmland near the river has rich alluvial soil. Even Minisink and Namanock Islands have been used for growing corn, although recently, one of the farmers began selling the topsoil by the truckload in anticipation of the lake. Sussex farms are largely vegetable truck farms. The poultry farms in Montague township had ceased to be profitable and were no longer in operation. The farms in the Tocks Island Lake Project and the Delaware Water Gap National Recreation Area locations were probably the best farms in the county.[13]

There are two varying themes which describe the opposing forces at work on the potential viability of those farms were they to have continued to operate. Both were expressed in Volume V, Appendix K, of House document 522.

"with a growing population, the Basin and the nation can look forward to an increasing demand for food...cropland and grazing land must be made to yield more products per acre with minimum year to year fluctuations."[14]

"it is only reasonable to expect that, with the continued rapid growth of suburban developments, superhighways and industrial expansion, the withdrawal of land from agricultural use will continue and accelerate."[15]

To some extent, the pattern of farming uses being squeezed out by the economy and outward pressures from expanding urban regions has been felt in this area. Farming has declined. For example, in Sussex County there were 1,120 farms in 1954, 826 in 1959 and 550 in 1966.[16]

Part of the problem comes from increasing difficulty in obtaining supplies, equipment and labor; part is from the burdens of higher and higher taxes. And part is from the irresistable offers that inevitably come from land developers.

Both New Jersey and Pennsylvania have enacted legislation to help retain lands in agricultural use. In Pennsylvania an act called the "Clean and Green" Act was implemented to provide tax relief to the farmer. In New Jersey a similar Act, called the New Jersey Farmland Assessment Act, was passed in 1964.

"The highest real estate taxes in the United States have helped to force many New Jersey farmers out of business.

"In 1963 New Jersey voters overwhelmingly approved the amendment to the State Constitution that made possible the Farmland Assessment Act of 1964, which

makes New Jersey farmland available for farming on a basis more competitive with farmland in other states.

"Careful administration of this Act should do much to revitalize agriculture in the Garden State. 'Fringe benefits' of this Act should ensure green acres and open spaces that will enhance the beauty of New Jersey for all citizens, and retard premature development."[17]

Results so far indicate that the legislative measures do not impose severe enough penalties and thus are not very effective in accomplishing their purposes.

If the lake and park proceed, some excellent farmland will be permanently lost to agricultural use. The criticism is valid, the consequences unavoidable; but in the Tocks Island area uncertainty about farming's future reduces somewhat the weight of this concern.

It is proposed by the National Park Service that these losses be mitigated by educational and demonstration farm programs. Citizen organizations have explained that although this intent is in the right direction, a few demonstration farms cannot replace the amount of tillable productive land which would be lost by the Tocks Island project.

1. Public Works for Water Power and Development and Atomic Energy Commission Appropriation Bill, 1975. Hearings - Subcommittee of the Committee on Appropriations. House of Representatives 93rd Congress. Part I, Corps of Engineers, p. 371.

2. Bramhall, Mr. William, National Park Service, Denver, telcon, February 4, 1975.

3. Swenson, Mr., Allentown, Pennsylvania Council, Boy Scouts of America, telcon, February 7, 1975.

4. Brown, Mr. John, George Washington Council, B.S.A., Trenton, New Jersey, telcon, February 7, 1975.

5. Tennite, Mr. Arthur, Bergen N.J. Council, B.S.A., telcon, February 7, 1975.

6. Wallace, Mr. Denver and Bootzin, Mr., Orange Mountain Council, N.J., B.S.A., telcons, February 7, 1975.

7. Davis, Mr. Ken, formerly of Thomas Edison Council, now with Robert Treat Council, Newark, telcon, February 7, 1975.

8. ibid.

9. Delaware River Basin Commission criticism card file.

10. Edminster, Mr. Lowell, Soils Conservation Service, and Withrow, Mr. John, County Agriculture Agent, Stroudsburg, Pa., telcons, February 6, 1975.

11. Staley, Mr. Joseph, County Agriculture Agent, telcon, February 6, 1975.

12. Serfass, Mr. Harry, Warren County Agricultural Extension Service, telcon, February 7, 1975.

13. Barber, Mr., Sussex County Agricultural Agent, telcon, February 7, 1975.

14. House Document #522, Appendix K, Vol. V. p.3

15. op. cit., p.4

16. Snyder, Eric K., DWGNRA Impact on Sussex Co., N.J., October 17, 1975.

17. Leaflet 390-H, Farmland Tax Adjustment for Farmland Owners Who Qualify and Apply, Cooperative Extension Service, Cook College, Rutgers University.

XI.E.3. USE OF LANDS IF DEAUTHORIZED

Some critics have supported the Corps' concern that the natural beauty of the region be preserved, but have objected to the dam and lake and fear that should the project be deauthorized the Corps would put the acquired land on the market with property going to the highest bidder. The end result could be a return to bulldozers and development.

The discussion as to whether or not the Delaware Water Gap National Recreation Area would continue to exist if the Dam is deauthorized, is the subject of greater discussion in Part D, Chapter XIX.

XI.E.4 MUNICIPAL VIABILITY

Commissioner David Bardin of the New Jersey Department of Environmental Protection remarked that the land acquisition in some areas has had some pretty direct and pretty severe impacts on municipal viability.[1]

This impact is most pronounced on the New Jersey side of the river where two townships will be acquired in their entirety. These are Wallpack in Sussex County and Pahaquarry in Warren County. These consequences are unavoidable for completion of the projects as authorized. The delays and time period extension over which this acquisition has proceeded, however, have led to a gradual diminution of taxpayers, of voters, and of residents. This places greater and greater strains upon those who remain and upon the fiscal and governmental functions still required. A discussion of the tax issue

(Note: Sources are noted on Page XI-90)

has already been included in Part D of this chapter. In Pahaquarry 35 voters still remain, though all the land has been either acquired or now condemned.[2] The town of Walpack has been 90% acquired.

In Pennsylvania, no townships are so severely affected, but the Villages of Bushkill and Dingman's Ferry, both in Pike County, are scheduled to be inundated. In each village the water company is still operating with no reduction in its costs, but the number of customers has been gradually reduced along with the attendant income. The companies will have to continue as long as the last customers remain, but there is no means to compensate for their continuing cost of operation.

The Volunteer Fire Departments will have to relocate and as private organizations they do not qualify for Federal assistance to replace their facilities under PL 85-500, the Rivers and Harbors Act of 1958.

Both villages will disappear as entities. Dingman's Ferry inhabitants have relocated in scattered areas of higher ground, but a cohesive town identity will no longer exist. A townsite property that had been purchased now becomes affected by the alignment of relocated Route 209.[3]

In Bushkill, according to Lehman Township Planning Commission Chairman, Carl Rohner, the old village center will be replaced by several new ones that will spring up in new developments. He gave as examples, Rustic Acres, Pine Ridge, Pocono Mountain Lakes, Pocono Ranch Lands, and Wildwood Estates.[4]

A sense of regional history and generation transfer cannot help but suffer from the loss of these river valley town centers.

1. Bardin, Commissioner, Delaware River Basin Commission, November 18, 1974, p. 229.

2. Interview with Robert C. Shelton, Jr., Assemblyman, District 15, N.J., January 18, 1975 and telcon with Pahaquarry Town Assessor Mrs. Sadie Van Camp, February 6, 1975.

3. Sullivan, Col. Daniel, Pike County, telcon, February 7, 1975.

4. Rohner, Mr. Carl, Lehman Township Planning Commission Chairman, telcon, February 7, 1975.

XI.E.5. UNCONTROLLED DEVELOPMENT

"It is said that even the most careful planning..... cannot prevent massive depradation of the unspoiled wilderness."[1]

"Only 10% of the Minisink area will be protected (between Port Jervis and the Delware Water Gap) from development as part of the federal preserve and the other 90% will be open to development."[2]

These and many other similar criticisms have dealt with the concerns of the effect of construction of the dam and creation of the Recreation Area on the growth of the surrounding region. Detailed evaluation of these impacts on the area is the subject matter of Part E, Chapters XXII - XXV.

1. "Tocks Island To Be or Not To Be", League of Women Voters, Interleague Council to the Delaware River Basin, p. 6.
2. Matheson, Mrs. Joan, Delaware River Basin Commission, card file of criticisms.

XI.E.6 FLOOD PLAIN LAND USE

In the preceding sections of Chapter XI, Part E, land use issues have been discussed which are primarily related to land uses in the Tocks Island region - the primary impact area. Another series of land use concerns deals with the flood plain below the Tocks Island Dam.

To some extent, the criticisms are in relation to the discussion of non-structural flood plain management, i.e. flood plain zoning, flood proofing, and relocations as alternates to the structural solution of building the Tocks Island Dam. An evaluation of these alternatives is presented in Chapter XV. A brief discussion has also been presented in Part B of this chapter under Engineering concerns. Other criticisms deal with the extent of existing development in the flood plain and the prospects of future development. This subject has been treated in Part A, Chapter II.

XI.E.7 RATE OF RUNOFF

As land uses change in the area surrounding the dam and lake, more construction of all kinds (buildings, roads and parking areas) will supplant areas now in a natural state.

Rate of run-off of rainwater and melting snow will be effected, since the surfaces will have become more impervious. Water will not be lost to the overall water supply, as it will eventually reach streams, the river and/or the lake. But other considerations regarding erosion and sedimentation could become problems.

Proper design considerations, including adequate drainage facilities, will minimize the effects of construction. In the Supplemental Data Report and Supplemental Information to the Final E.I.S., T.I.L.P. 1974, an effort has been made to point out these problems and to consider them in the design procedure. Concern has been expressed about the entering of mud and silt materials into streams as a result of the stripping of vegetative cover in areas under construction. It has been pointed out that the production of some mud and silt in areas under construction cannot be avoided, but their introduction into streams can be prevented. The Tocks Island design provisions (Design Memos) provide environmental safety details for rip-rapping of temporary ditches, temporary berms along the edges of shoulders to prevent the erosion of the embankment until the ground cover takes over and temporary settlement ponds for runoff. The long term effects of construction will be lessened by landscaping and treatment of cut and fill slopes, through selective planting of trees, shrubs, special ground cover, additional seedings and topsoiling. These plans for control of soil erosion and sedimentation are being developed in accordance with the requirements of the Pa. DER Rules and Regulations on Erosion and Sediment Control, especially the Pennsylvania Clean Stream Law along with Penn DOT, USDA Soil Conservation Service and COE protection measures.

XI.F. TRANSPORTATION CONCERNS

The Tocks Island Lake Project will affect transportation in two general areas: (1) the impact of the Project on existing highway and transit facilities and (2) the effect of planned transportation improvements on residents and businesses in the local four-county area of New Jersey and Pennsylvania. A full discussion of transportation issues may be found in Chapter XXV.

XI.F.1 IMPACT ON EXISTING TRANSPORTATION FACILITIES

Elected officials (state, county, township), appointed officials (planners, engineers), civic organizations and private citizens, are concerned with the adequacy of the road system to accommodate current peak hour traffic and traffic resulting from four million additional visitors to DWGNRA. This issue has been widely discussed, especially in Sussex, Warren, and Monroe counties. Some planning officials have detailed the weaknesses of their roads system, such as narrow bridges, dangerous curves, and through routes in densely settled areas. Other county officials have recited from personal experience the difficulties of weekend driving in summer (when people visit the parks) and winter (during skiing season). It is not uncommon to find summer Sunday afternoon traffic tie-ups extending for five to ten miles. Generally for residents living around (or traveling near) a popular recreation area, weekend driving is frustrating and at times discouraging.

Although planned highway improvements would expedite the movement of through traffic, tourists would, nevertheless, drive into and through local communities for various services not available at the freeway interchanges.

The approaches to specific recreation sites in New Jersey will have to be reached via existing local roads which will bring congestion to areas like Blairstown, Swartswood and Stillwater. The distribution of area visitation along the existing and proposed highway system is fully discussed in Part E, Chapter XXV, Sections B and C.

The determination as to whether the existing transportation facilities, particularly the highway system, are adequate is documented in Chapter XXV, Section A. Future traffic levels, with and without the additional Tock Island generated demand, is estimated and compared with the roadway capacities of the existing highways. The required improvements to accommodate the expected levels of visitation in addition to normal traffic growth are presented in Chapter XXV, Section C.A.

There is some concern that the influx of additional cars will create high levels of air pollution in violation of Federal air quality standards. Even with the recent delays in the effective implementation date of legislated emmissions standards, it is expected that, by 1985, automobile emissions will be reduced to less than one-tenth of the emissions produced by pre-1970 automobiles. The result of this reduction, considering the vehicle-age mix for traffic in 1985 especially for areas like the DWGNRA, is that no air quality standard will be violated due to automobile emissions.

XI.F.2 EFFECTS OF PLANNED TRANSPORTATION IMPROVEMENTS

Presently, even without the Tocks Island Lake Project, improvements are

needed on the existing highway system in Sussex and Warren Counties to maintain an adequate level of traffic service. Local residents fear, however, that these improvements would attract developers and result in unwanted suburban-type sprawl. The construction of the Foothills Freeway, for example, would require the taking of prime residential properties, alter the scenic value of the Kittatinny Mountains and increase traffic on local two-lane roads leading to the freeway interchanges. As discussed in Chapter XXV, the Foothills Freeway may not be necessary if other alternatives are implemented (Chapter XXV, Section C.4).

In Pennsylvania, there is also concern about the taking of property for highway improvements; in particular, the relocation of Route 209 in the area which will be inundated by the proposed reservoir. South of the dam, residents of Monroe County are concerned about future traffic congestion on the remaining sections of Route 209 to the south where no decision as to proposed major improvements have been made at this time.

Further, there is concern that the new highways will take prime agricultural acreage. In selecting the optimum alignment for a new highway, agricultural land considerations are important, but there are other environmental, land and social values which must be weighed, including transportation service, topography, soil conditions for construction, groundwater, surface water, wildlife habitats, urban land use, utilities, and recreational, historical and archeological sites. State transportation officials are keenly aware of the above considerations and positive efforts would be made to limit or minimize the taking of prime acreage for new highways.

There is concern (expressed at the October 1974 public hearings) about damage to existing local roads because during the construction of the dam and appurtenant facilities (including new highways), heavy equipment will use local roads to reach construction sites. To insure that these local roads are restored to their original condition, it is standard procedure to include in the construction specifications a requirement that contractors resurface and restore roads affected by construction. In many cases the restored roads are superior to the original ones.

The transportation improvements are presently being planned primarily on private automobile usage. Local residents believe that automobile traffic could be reduced if adequate and attractive public transportation is provided. The modal split between public and private transportation is discussed in Chapter XXV, Section B.2 (c)(2). Improvements to public transportation are discussed in Chapter XXV, Sections C-1, C-2, and C-3.

XI.G. SOCIAL CONCERNS

The concerns described below express the "personal" concerns of residents of the impact area as well as visitors who enjoy the area for its recreational benefits. For a more complete discussion of these issues see Chapter XXIV.

XI.G.1. LIFESTYLE CHANGES

According to local officials, the primary impact area is experiencing pressures being brought on by urbanization which will be further accelerated by the Tocks Island project. With the highway system currently serving the area, New York City is one to one and a half hours away from the eastern edge of Pennsylvania and northern New Jersey counties -- this makes a daily commute between these two points acceptable. Pike County, Pennsylvania, for example, with a 1970 population of approximately 11,500 has 35 subdivisions under development (ranging in size from 500 to 4,000 acres). If these subdivisions were built out, Pike County officials estimate an additional population of 35,000 would result. For prospective buyers, the DWGNRA adds a plus to the existing Pocono attractions. Services associated with urban area -- public sewers, water, sidewalks, etc. — are already being requested. Other services such as medical, fire, police, and roadways would require expansion and improvement according to local officials. Although many new homes within the impact area could be considered "seasonal", local officials nevertheless point to the increase in demand for public services as a sign of permanence.

In Vernon Township, N.J., local businessmen have estimated that the Tocks Island project will further intensify the growth pressures already present. This increased growth is illustrated by a heavy demand on the public school system. Until 1968 "and for the previous 200 years" the township existed with one eight-room schcol building. Since 1968, five new school buildings have been constructed and another is planned.

Many local officials have already noted ads in the New York City area newspapers offering homesites "near Tocks Island" -- if the project is implemented their prediction is that general development pressures will be felt throughout the primary impact area, with some of the following characteristics. Accelerated population growth will result in increased traffic, tract housing, large shopping areas, strip commercial development as well as new demands for medical services, schools, and cultural pursuits. All of these factors would alter the relatively simple life-style that exists today. Threatened would be the tranquil, pleasant semi-rural environment where peace and safety are cherished values.

XI.G.2. RECREATION IMPACT

Discussed below are recreation concerns expressed by local residents (through whose jurisdictions visitors will travel), as well as the concerns of organizations representing some visitors, such as, fishermen and swimmers.

XI.G.2.(a) Origin, Type and Quantity of Visitors

Local officials and residents are presently disturbed by the estimated number of outside visitors who will visit the Delaware Water Gap National Recreation Area annually. Already in conflict are the cultures of the young, minority city dwellers and the older, rural residents. This local concern was vividly illustrated by the presence of the "squatters", some 50 men, women and children in their 20's and 30's who began to occupy some 21 dilapidated buildings along the Delaware River in the late 1960's. In early 1974, they were evicted by U.S. Marshals. Although it was reported that for many young people life in this commune had been the "best times of my life", the local residents had resented them. Local officials believe that while many visitors will come from the suburban areas of New York and Philadelphia, a certain percentage of "trouble-makers" will also be attracted to the area. Residents of the impact area have expressed concern with drug and alcohol abuse, vandalism and crime.

Underlying the concerns, expressed by area residents, about park visitation is the implied or occasionally expressed racial issue. Area residents and elected officials have stated that they expect the park to be visited by a large number of minority groups from Philadelphia and New York City. The basis for their expectations is the fact that the park is already making an appeal to a diversity of racial and cultural groups. Concerns expressed center not so much on minority group visitation of the park itself but their activities, cultural expressions and lifestyles, (as expressed in the communities) before and after they leave the park. The reasons for concern are due to differences in customs between local people and outside visitors.

Local officials and residents recognize that visitors to the Delaware Water Gap National Recreation Area cannot be "screened". To attempt to do so would be illegal and undesirable. Visitors to the area will represent a diversity of lifestyles. Local officials and residents desire an effective public safety program so that persons committing illegal acts are apprehended and brought to justice.

There is wide disbelief among local officials and residents that the numbers attracted to the National Recreation Area annually can be controlled. There is a lack of understanding as to the logical basis for first establishing visitor limits at 10 million (considered to meet a large volume of the unmet needs for the northeastern part of the U.S.) and later at 4 million (a limited number which acknowledged potential local adverse impacts). Although the number of visitors to the park can presumably be limited on the basis of design programming, user fees and other devices, local residents are not convinced that the number of annual visitors will be limited.

During peak periods when the park is over-capacity, visitors could be diverted to other recreational opportunities in the area.

XI.G.2(b) Boating

Opponents of the Tocks Island Lake project assert that the character of boating would be negatively altered with the lake. A free-flowing river with inlets, eddys and changing currents encourages the use of canoes and other smaller craft, while a lake characterised as a large static body of

water will invite an increase in power boats. One public official has expressed deep concern that the lake would become clogged with 25 to 40 foot yachts.

Although the same boats which have been utilizing the river can make use of the new lake, public interest groups have stated that the wilderness aspects of boating would be eliminated.

The concern that power boats will take over can be ameliorated through proper planning to regulate the size and limiting the areas where they may cruise. The complaint that the lake will alter the current boating pattern is unavoidably true, but individuals expressing concern in this area believe that any potential abuses of power boats can be controlled through wise regulation. For further discussion see Chapter XVIII.F.1 (Boating). (It appears that the Clarke and Rapuano plan intended to address this question as their Table of Contents indicates this subject in part II.J and K. However, these pages were not included in the plan document made available to the consultant.)

XI.G.2(c) Swimming

Opponents of the Tocks Island project have criticized the Corps of Engineers for planning "Coney Island" style swimming areas in artificially constructed, overconcentrated beaches. These opponents argue for more decentralized swimming areas in enhanced natural locations. Environmentalists have stated that swimmers will have to contend with the reservoir's occasional drawdowns which could be considerable during summer droughts. These

drawdowns will alter the shape of the beaches and might leave unsightly mud flats exposed. An additional concern for swimmers is the quality of the bathing water itself, with eutrophication a potential problem.

The Corps of Engineers has acknowledged the above concerns and is attempting to ameliorate the situation. The Corps has stated that the beaches will be enhanced with sand to cover occasionally exposed areas. Furthermore, they contend that eutrophication will be kept under control thereby not affecting swimmer discomfort and health. Critics say the Corps has failed to appreciate their desire for smaller, natural beach areas. Assuming the existence of the lake and the programmed visitor level, "smaller natural beaches" are unrealistic. The proposed large beaches are an unavoidable consequence if the lake is constructed. Without the lake, the DWGNRA could plan for smaller swimming areas located throughout the park. This would satisfy those who favor the National Recreation Area without a lake.

For further information regarding eutrophication refer to Chapter IX A and Section XI.A.2 of this Chapter. Additional material regarding drawdown will be found in Section XI A.3(a).

XI.G.3 DESTRUCTION OF NATURAL AND HISTORIC HERITAGE

Historical documents reveal that the river valley floor is dotted with historic settlements, trails, and an ancient road. Those who wish to

preserve the historic heritage of the valley point to the evidence of Indian Settlements, Dutch settlements of the mid-1670's and later English developments which would be lost for future generations should the dam be constructed. For a discussion of historic and archeological impacts of TILP-DWGNRA, see Chapters X.A and XXII.

XI.G.4 DESTRUCTION OF PROPERTY

Residents within the impact area have contended that there has been unnecessary bulldozing of properties acquired by the Corps of Engineers. Historic homes, inns, and farms in good condition are alleged to have been destroyed. Inasmuch as control would appear to be the initial objective of government ownership, local residents and officials have not understood why sound property should be destroyed. The preservation of acquired properties still standing is considered wise in case the Tocks Island dam is not authorized for construction and the DWGNRA stands on its own. Should this occur, the remaining properties which are suitable could serve as restaurants, inns, shops, service buildings and the like. Most importantly, through the re-use of older structures, future visitors will not have been deprived of experiencing the history and culture of the area.

Residents and preservationists state that their concerns could be partly mitigated if the destruction of properties they consider sound was ceased and the government maintained acquired buildings (rather than allowing them to become dilapidated) until some final decisions were made regarding their usefulness.

XI.H. ENVIRONMENTAL CONCERNS

XI.H.1 AQUATIC BIOLOGY

The impact of a dam upon the diverse and productive aquatic communities in the river and estuarine waters has received considerable attention. Principal areas of concern involve the Delaware Bay oyster industry, the anadromous American shad and the eventual species composition of the reservoir.

XI.H.1(a) Oysters

If the natural river flow is decreased by reservoir operations, salt water may intrude farther up the river than is presently found. Movement of the saltwater gradient upstream could affect the oyster population by extending the range of such predators as the oyster drill into presently unaffected oyster beds. Similarly, the distribution of other species which compete for food and space with the oysters or are themselves predators is regulated by salinity. MSX, a protozoan parasitic oyster disease, is apparently salinity-sensitive as well. The possible adverse effects of decreased flow upon the oyster industry are readily apparent. Obvious mitigation involves maintenance of natural river flows but conflicting commitments may prevent freshwater releases from matching the present summer values. Chapters III and VI.E. analyze the relationships between freshwater flow and the salinity gradient (including the question of required flow needed to maintain the present salinity barriers).

Chapter IX.H. deals directly with the subsequent impact of altered salinity gradients, if projected, upon the oysters.

XI.H.1(b) Shad

The American shad is one of the most popular sport fish in the Delaware River. Shad are anadromous fish that migrate to areas upstream of Tocks Island for spawning. Concern has been expressed as to the ability of the shad to carry out a successful spawning run with the hindrance of a dam and impoundment. The shad may not be able to locate and/or negotiate the fish ladder (regardless of design), find and follow currents within the reservoir which will orient the migrating school in an upstream direction, or manage to reach a suitable area at which they can spawn.

If the shad do manage a successful spawning run, the survival rate of the eggs and juveniles may be decreased. Shad eggs are slightly denser than water and, after they are released, slowly sink. They are carried by the current along the gravelly river or tributary bottoms, sometimes for several miles. Concern has been expressed that silt in the reservoir may cover the shad eggs and interfere with proper oxygen exchange.

The downstream movement of the fingerlings in the fall may be adversely affected. The young shad move in a random fashion, often heading lazily upstream as the current carries them towards the ocean. The ability of these fish to traverse a large, relatively still, body of water is questioned. The possibility of increased predation pressure in the reservoir adds to this concern. As well, the potential occurrence of the nitrogen gas bubble disease in those shad (and reservoir fishes) carried over the spillway or caught in nitrogen super-saturated waters downstream may further reduce the success of juvenile and adult migration.

Suggestions for the preservation of the shad range from proper design of the fish ladder facility to the placement of screens on the pumped storage intakes to maintenance of flow rates through the reservoir, over the fish ladder, and downstream at levels navigable by the shad. The likelihood of successful permanent passage by the American shad, incorporating all the above criticisms and concerns, is dicussed in IX.C.2.

The period of construction could be the most crucial one for maintaining the natural shad river population. Shad will not pass through dark passages and, thus, means of temporary passage must be implemented. During the channel-diversion phase of construction it is feared that increased flow rates through the narrow channel and tunnel

might prevent movement of the shad to water upstream. The possible impact of a heavy siltation load upon the river fishes, especially during the years of construction, has been raised as well. Chapter X, Construction Impacts Upon Fish, answers these questions and the corresponding mitigation measures suggested.

XI.H.1(c) Species Composition

The maintenance of Tocks Island Reservoir as a lake suitable for game fishing may be a problem. Claims have been made that similar reservoirs have developed a poor quality fishery. These reservoirs have experienced a high degree of game fish predation and stunted fish growth resulting in an overabundance of sunfish and perch. Predators (e.g., chain pickerel) that prey upon these panfish are not likely to survive in Tocks Island Lake because of the lack of nesting sites (e.g., rooted aquatic vegetation). Carp are expected to be a problem in the lake unless they are controlled. Carp are known to eat the eggs of more desirable fish and stir up sediment which will settle and suffocate unhatched eggs. Similarly, the white sucker population may increase significantly and thus overfeed on benthic organisms, especially aquatic insects. They could become a problem in the upstream Delaware during their spawning run and through the use of the area as a nursery grounds by competing with more desirable species. In general, the expressed advantage of recreation in relation to fishing may be lessened if trash fish dominate the lake ecosystem.

The Flatbrook River, which would be heavily inundated by the impounded waters, is one of the best trout streams in New Jersey. The lake probably will not accommodate a cold-water fishery as surface temperatures will be too warm and bottom waters will be lacking in oxygen. Even with the establishment of a sizable lake trout population, though, the potential loss of challenging stream fishing is considered significant by avid trout fishermen.

Temperature fluctuations due to pump storage or release waters from the dam may have an adverse impact upon the trout and other river fishes. It is also possible that the impoundment will suppress populations of aquatic insects such that extremely desirable food sources may be depleted or altered in species composition. Thus, the shoals and shallow benches along the river, which are very productive areas, will no longer support the species and/or numbers they do at present.

Concern that any type of established reservoir fishery would be subject to greater parasitism has been expressed. The sea lamprey spawns in the upper reaches of the Delaware River. If the lampreys become land-locked they may take on their parasitic form, spawning in the tributaries and using the impoundment as a feeding ground. Lamprey usually kill the fish upon which they feed (e.g., trout).

At present, the lampreys do not threaten river fishes as they do not feed on their spawning run. It has been suggested that Pepacton Reservoir may already be the site of a race of lake-locked lampreys.

In addition, the bass tapeworm may be able to greatly increase their numbers in a still body of water and affect more fish than would be possible in the free-flowing river state. This parasite is especially damaging to large- and small-mouth bass populations, both excellent game fish.

A potential loss to the commercial American eel fishery in waters above the proposed reservoir is feared. Increased predation upon elvers in the impoundment and the possibility that many elvers will remain in the impounded waters instead of moving upstream could adversely affect the present eel fishery, especially in New York waters.

The eventual ecological balance of the lake and the potential for disruptive influences are treated to a greater depth in Chapter IX.C.1, inclusive of all points referred to above.

XI.H.1(d) Reservoir Operation (Pumped-Storage Generation/Drawdown)

The operation of pump storage and drawdown operations will cause fluctuations in water level. The primary concern for aquatic life is impairment of the spawning activities of desirable game fish. Spawning areas would be subject to changing water levels that could expose nests. However, at this time,it is not known which species of fish will be affected. Drawdown may be one technique to manage the trash fish population by lowering the water level when trash fish are nesting and exposing the nest. Thus, the eggs of trash fish would dry out

and the population would equilibrate at a lower level. Drawdown to control rough fish may be impractical on a reservoir of this size, especially at the time of year it would have any possibility of effectiveness. However, there is concern that some of the more important fish predators, such as pickerel, Northern pike, and muskellunge would also be eliminated, since they spawn in very shallow water.

Suckers, a trash fish, spawn in the smaller stream tributaries. These fish do not enter the main body of water until they are adults. Therefore, drawdown is not expected to affect the spawning activities of the sucker population. Experimental work in ponds which underwent artificial drawdown led researchers to believe that the species tested (bluegills, large-mouth bass, small-mouth bass, pumpkinseed, walleyes, and yellow perch) could adjust and reproduce successfully in a fluctuating environment.

In summary, drawdown could affect the eggs of numerous fish species within the reservoir. Even though the time of the exposure may not be sufficient to kill an egg, it does make the egg less resistant to extreme fluctuation in temperature or dissolved oxygen. It has been suggested that simulation studies more closely approximating Tocks Island drawdown conditions be initiated to determine whether drawdown may be used to decrease trash fish populations while promoting game fish dominance.

In addition, vegetation may have difficulty becoming established in any of the areas exposed by fluctuating water levels due to drawdown and pumped storage operations. Lack of vegetation will increase the chances

of erosion and bank instability. The resulting turbidity and heavy sedimentation may be detrimental to shad and pickerel eggs. The eggs of these species may suffer from suffocation and abrasion. The nest-building activities of some of the local waterfowl may be adversely affected as well. Lake shores lacking vegetation are also expected to greatly limit the fish and invertebrate species/diversity. See Chapter IX.B. and Section XI.A.3(a) for further discussion of drawdown. See Section XI.C.1 for other considerations regarding pumped storage.

XI.H.2 TERRESTRIAL BIOLOGY

XI.H.2(a) Wildlife Habitats

Among the specialized habitats destroyed will be freshwater marsh and riparian woodland communities. The steepness of the slopes along the reservoir shoreline especially on the upper reaches strongly limits potential compensatory habitat. Water fluctuations may also prevent the re-establishment of aquatic rooted vegetation, although seeding of native species may mitigate this deficiency somewhat (IX.C.3). Among the losses will be significant bird habitats. Adjacent habitats to the project area are marginal and cannot support all the animals that will attempt to seek niches. Most adversely affected will be deer as detailed in Chapter X.

Concern has been expressed regarding the time period needed for a wildlife balance to be re-established. Some parties expect a wildlife imbalance or upheaval within the ecosystem for up to 30 years following construction. A more realistic time interval for re-establishment of the ecosystem balance outside that area

destroyed by brush clearing and inundation is approximately 10 years.

The prevalence of disease and nuisance vectors, such as mosquitos, ticks, rats, deer flies, wasps, black flies, etc., is questioned. Encephalitis is one such disease transmitted by a vector causing possible fatalities in humans and livestock. A coordinated vector control program is a necessity within the Tocks Island region environmental protection system. The possibility of vector outbreaks may be increased by the development of the dam (construction phase) and the ensuing fluctuating water level in the reservoir. As explained in Chapter IX.C.3, frequent fluctuations of the water level actually will decrease the potential for vector outbreaks.

XI.H.2(b) Migratory Wildfowl

The lake undoubtedly will attract more migratory waterfowl relative to the waterfowl now seasonally visiting the freeflowing river between Port Jervis and Tocks Island. However, based on populations using nearby reservoirs, this increase is not expected to be very substantial. As discussed in Chapter IX.C.3, preferred avian food items may be lacking if productive marsh-type habitats do not re-establish. The question of an increased eutrophication potential due to the wastes of an enhanced duck and geese contingent on the reservoir is treated in Chapter XI.A.

XI.H.2(c) Wildlife Mitigation Areas

Legitimate concern has been expressed that the 880 acres set aside to mitigate loss of habitat is not just compensation to offset the expected adverse impacts. The reasoning behind such thoughts is

that the 880 acres of acquired lands will already have an established faunal community and will not be able to accommodate the population of the displaced animals. If the displaced populations did actually migrate to the wildlife compensation lands, very fierce competition would more than likely result. Also, it is almost impossible to regain the diversity of habitat types which will be lost due to construction and inundation by compensating with other lands. At best, it is doubted that such land could ever restore the habitats lost within the basin.

XI.H.3 AIR POLLUTION

Concerns have arisen about air pollution caused during construction as well as during the heavy traffic expected from the actual operation of the reservoir. If vegetative material removed during clearing operations was burned, particulate primary standards would surely be exceeded. The resulting loss of forested land will also reduce the capability of oxygen production through photosynthesis. Considering the low density of receptors near the site, construction-imposed air pollution loads will not have a significant effect, nor will the loss of oxygen-producing vegetation as algal growths in the lake will tend to compensate for the reduction. Because the Army Corps of Engineers does not, at this time, intend to burn cut material, no mitigation measures are suggested.

XI.H.4 LOSS OF 37-MILE FREE-FLOWING RIVER

The upper reaches of the Delaware River including the Tocks Island Area are claimed to be perhaps the only normally functioning section of the free-flowing Delaware River. The uppermost reaches of the river are presently under the influence of New York State reservoirs, while the lower reaches are affected by heavy industrial use and ship traffic. Therefore, loss of the free-flowing stretch of the Tocks Island area is, in actuality, a loss of a major portion of the last freely flowing part of the river.

There is great concern over the question of whether the Delaware would retain its characteristics of a free-flowing river downstream if the dam were built. The main concern is with those environmental consequences which at this time have not been anticipated but, after construction, may make impoundment undesirable. The expected water quality and biotic effects of the dam are covered in Chapter IX.H. A potential mitigation measure is the operation of the dam outlet works to simulate natural flows.

XI.I. PROJECT FORMULATION CONCERNS

Stated below are concerns and criticisms which are critical of either the underlying assumptions or methods of formulating (and justifying) the objectives of the Tocks Island dam and DWGNRA.

XI.I.1. ECONOMIC

Economic concerns associated with the project's formulation include the validity of the Corps of Engineers cost-benefit assumptions, as well as an analysis of which parts of the impact area's economy will benefit most from visitor trade.

XI.I.1.(a) Validity of Cost-Benefit Assumptions

There is widespread concern that the Corps of Engineers cost-benefit analysis is insufficient to justify the project's implementation. Among some critics, the methods and specific inputs are questioned; others find the analysis confusing and contradictory.

Most critics attack the cost-benefit analysis on recreation. They point out that while the dam was originally conceived for flood control and water supply purposes its objectives have now shifted so that recreation accounts for 44 percent of the benefits. Residents of the primary impact area have asked the question, "why should the government spend $100 million on recreation when the area already enjoys supurb recreation opportunities?"

Analysts taking a slightly different tack have noted that the Corps of Engineers is still using the 10 million annual visitor figure, (instead of the 4 million figure established by the DRBC) in order to fully exploit potential recreation benefits.

Some opponents who may have initially favored the dam are now expressing doubt as to whether the benefits can be justified in light of soaring construction costs. Others have indicated that the project also involves a serious question of national priorities and have suggested that other more compelling social needs outweigh the need for the Tocks Island project.

It has also been submitted that many hidden costs, attributable to this project such as liquid and solid waste disposal, highway construction, additional police and fire protection, medical and hospital facilities have not been adequately considered and calculated in the cost-benefit analysis.

A major criticism of the Corps of Engineers benefit-cost analysis deals with the fact that the recently adopted "Principles and Standards of The Water Resources Council" have not been applied to the Tocks Island Lake project. Basically, these new principles and standards call for raising the discount rate from 3-1/8% to 5-7/8%, increasing the cost per visitor's recreation day by 50% from the current $1.35 and for the evaluation of environmental and social well-being benefits and costs.

The Corps contends that new principles and standards do not apply to the Tocks Island Lake project since it was authorized in 1961. Thus, the original and current standards used by the Corps were officially "grandfathered" under the current law.

This discussion of the validity of the cost-benefit assumption exposes the wide gap which exists between the Corps of Engineers and its critics. See Chapter XVI.B. for a more detailed discussion of this subject.

XI.I.1.(b) Project Benefits and the Local Economy

Local officials and businessmen project that direct benefits will be realized by businesses which provide a service to the visitors of the Delaware Water Gap National Recreation Area -- restaurants, service stations, commercial camping areas, suppliers, and the like. A minimum number of motels will be developed to accommodate visitors who are not day trippers. Local businessmen state that the areas existing business establishments -- retail stores, banks and others -- will experience only a marginal impact.

The initiatives for major new businesses will likely come from outside the area, with local residents being used mainly for service level employment. It is estimated that tax revenues for these new businesses will pay their own way but excess revenues should not be expected to pay for the local jurisdiction's added service expenditures.

The Corps of Engineers has estimated that the added ratable tax base provided by increased land values and new investments in the primary impact area will help to offset the new service expenditures required. Local business leaders in the impact area have indicated that the Corps has misread the kind of development likely to occur. They conclude that positive impacts brought on by new tax ratables would be offset by the negative

impacts brought on by the Tocks Island project. (See Chapter XXII for further discussion.)

XI.I.2 RECREATION

Critics of the Tocks Island project disagree with the Corps of Engineers assumption that more recreational opportunities are needed in the project area. Residents are also fundamentally against an increase in the permanent and transient population in the impact area, which would result from additional recreational opportunities.

XI.I.2.(a) Existing Recreation Facilities Sufficient

Opponents of the project who favor "recreation" but not the National Recreation Area base their opposition on the stance that the area already enjoys a sufficient amount of recreational opportunities. As an alternative, a national historic area is supported. This would complement, they claim, existing recreational activity, moderating the number of people expected to attend. Proponents of this limited park use seek to preserve the archeological and recent historical aspects of the area.

Proponents of a "Delaware River Park" view two different approaches, limited use versus maximum use, as inherently irreconcilable. The first approach does not want the lake, thereby making it possible to limit visitation and preserve existing historic sites and pathways along the Delaware River valley floor. The second approach wants the lake, and maximum utilization in a variety of program areas. Proponents of a park

without the lake state that the distance between these two positions could be narrowed if the lake were not constructed and the recreation area limited to the annual visitation of 4 million people.

XI.I.2(b) Compatibility of TILP with DWGNRA

The compatibility of the Delaware Water Gap National Recreation Area (DWGNRA) with the Tocks Island Lake Project (TILP) has been previously analyzed in several documents, the prime and most recent sources being:

- the 1971 draft Environmental Impact Statement (EIS) DWGNRA prepared by the U.S. National Park Service (NPS).
- the 1974 Supplemental Data Report to the Final EIS on TILP prepared by the COE.

To provide a sense of scale and proportion, the proposed lake is 20 square miles, the COE intends to provide an additional 15 square miles of water related recreation activities immediately abutting the lake and the NPS an additional 75 square miles of upland recreation land in the DWGNRA, for a total project size of 100 square miles.

The views on compatibility presented in the above documents can be summarized according to the primary views of NPS and COE. The COE concludes from its analysis (6.2.16 of 1974 EIS) that the prime recreation attraction of DWGNRA is the water based activities provided by TILP and that without it, NRA would not be justified on an economic basis (no supporting calculations are given).

Hence, any possible TILP/DWGNRA land use or operational conflicts are insignificant in comparison with the above conclusion. NPS has assumed

the proposed existence of TILP in each of its master planning documents of 1966 and 1971, and these studies attempt to mitigate those negative impacts. However, NPS analyses of DWGNRA without TILP (the subject of Chapter XVIII) indicate its viability as an NRA without the lake-based recreation activities.

The major potential points of incompatability of TILP and DWGNRA fall under the following headings:

- operation of the lake (water level and quality)
- lake increment of NRA visitation and resulting loss of historic features

Under the present proposal, the reservoir is the central focus of the NRA. Both its operation and water quality are critical to the successful functioning of this recreation area. It is unfortunate that operation of both the lake and recreation area are in two separate jurisdictions, the former, the COE; the latter, the NPS. Strict coordination and contractual obligations will have to be established to assure:

- that water level fluctuations are minimized particularly in the summer season (this is discussed in detail in Chapter IX.B)
- that shoreline beaches and other shoreline activity areas be planned for operation with as much as 25 ft. of draw-down.
- that effluent both from the NRA facilities and that from contiguous areas receive adequate treatment so as not to impair the reservoir's water quality for swimming, and for its water

supply function. This implies the need for controls and public expenditures for both point and non point sources of potential pollution. (A detailed discussion appears in Chapter IX.F)

- that potential liquid and solid waste pollution from boating and any other activity on the reservoir receive adequate control and enforcement from NPS so as to not impair the water quality for swimming and water supplies.
- that the potentials for harmful levels of eutrophication be adequately controlled by the proper local, county and state agencies along with the NPS.
- that reliable controls be enforced for possible soil erosion and resultant reservoir sedimentation both from the construction of TILP and DWGNRA and its eventual operation, and from potential activities on private lands in the upper basin.

The other point of major concern, the potential increment of lake based visitation is discussed in detail in Chapter XVIII B. The criteria for evaluation, however, are based to some degree on as yet unavailable data, such as:

- a survey and analysis of DWGNRA's natural resources to determine which can be utilized for various types of recreational activities and be able to withstand adequately the human impact and those which require preservation and protection. This is the natural systems approach to determining the

capacity of the area and baseline data necessary for judging the impacts of intense water based recreation.

- a survey and analysis of the cultural and historic features found in existing and proposed land acquisitions to determine the degree to which the impoundment area contains features worthy of historic preservation under the NPS's historic site guidelines which implement its Congressional mandates. See Chapter XXII for further discussion of TILP-DWGNRA impacts on archeological and historic resources.

Upon completion of the above two analyses, a true determination of the compatibility of DWGNRA and TILP can be made in terms of comparing visitation level with natural systems holding capacity and historical features versus or in conjunction with a reservoir as a major visitor attraction. For further discussion of this subject see also Chapter X.C.

XI.I.3 COMPATIBILITY OF PROJECT MULTIPURPOSES

The basic plan of development and the multipurpose elements of the plan were designed using detailed procedures that are outlined and reviewed in Chapter VIII.A T.I.L. Project Formulation Review, Planning Criteria and Procedure. These procedures reflected an effort to comprehensively arrive at a balanced program of water resource development with maximum output from minimum investments.

The authorized purposes of Tocks Island Lake are water supply, flood control, on-stream hydroelectric power and recreation. There is concern regarding the mutual compatibility of the Project's various purposes.

Compatibility of recreation with the other three authorized purposes of the Project has been discussed in previous sections of this chapter and in Chapter X.C. With regard to the interrelationship of flood control, water supply and hydroelectric power, these purposes are all technical and have been studied and developed together in many similar projects. Provision of these three three functions in multipurpose dam projects presents no incompatible requirements nor any impossible restrictions on successful design. With respect to the compatibility of these three purposes with recreation, there are conflicts which will somewhat affect the recreational appeal of the Project.

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